NOTES

ON

EUROPEAN SURVEYS,

COMPILED UNDER THE DIRECTION OF

C. B. COMSTOCK,

MAJOR OF ENGINEERS, BVT. BRIG. GEN., U. S. A.;

BEING

APPENDIX HH

[IN PART]

OF THE

ANNUAL REPORT OF THE CHIEF OF ENGINEERS FOR 1876

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
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During the last and the preceding fiscal years there have been received at the War Department, through the Department of State, a series of papers containing much valuable information respecting the methods adopted by the military establishments of various European governments in carrying on their great national surveys. These papers have been sent from time to time to Major Comstock, (at whose request they were obtained,) who has had them translated. He has also compiled extracts of these papers, which will, no doubt, be found useful in the prosecution of the public surveys of the United States. [*Extract from the Annual Report of the Chief of Engineers*, 1876.]

PREFACE.

Numerous manuscripts, books, and maps relating to European surveys were sent to me by the Engineer Department in 1875 and 1876, for examination and report. They were carefully looked over, abstracts were made of such as were deemed most important, and these were, from time to time, forwarded to the Engineer Department for its use. Subsequently, it was deemed advisable to print them, that their information might become more generally available. It should be remembered that they are mainly memoranda for those familiar with such work, derived from data at hand. Considered as accounts of surveys in different countries, they necessarily have many imperfections.

C. B. C.

LAKE SURVEY OFFICE, *Detroit*, *October* 9, 1876.

CONTENTS.

MAPS.

CHAPTER I.

LAKE SURVEY OFFICE,
Detroit, Mich., April 25, 1876.

GENERAL: A large amount of material relating to European geodetic and topographical surveys has been sent to me in the last six months for examination. This material consists of pamphlets and manuscripts relating to organizations and methods used, and of maps showing the results of the surveys.

From the descriptions of organizations and methods I have selected such as seemed of most interest to those concerned in such matters. I have had the maps examined as to their construction, execution, and contents.

Selections from the papers and notes upon the maps are annexed, giving a good deal of detail in reference to the surveys, and also photo-lithographs of some of the maps.

Perhaps some general remarks upon them may not be out of place

ORGANIZATIONS.

In GREAT BRITAIN the survey is called the ordnance survey, and is carried on by officers of the royal engineers, Lieutenant-General Sir Henry James having been for many years at its head. December 31, 1874, there were employed on it 19 officers of royal engineers; 4 companies of royal engineers containing 121 non-commissioned officers, 243 sappers and 8 buglers, 1,000 civil assistants of different grades, and 448 laborers.

In PRUSSIA the trigonometrical, topographical, and chartographical work is intrusted to the staff corps of the army, while the geodetic work in connection with the "European measurement of degrees" is in charge of the Geodetic Institute, whose head is Lieut. Gen. J. J. Baeyer. In 1875, 43 staff officers were employed on the survey, together with a large number of gunners, civil assistants, and laborers.

In AUSTRIA, the survey of the Empire is intrusted to the Military Geographical Institute, an organization which has a general at its head and is under the war department. Its members are officers, military officials, civil assistants, non-commissioned officers, and workmen. In 1875 it employed 1,258 persons, of whom 283 were army officers varying in rank from lieutenant to major-general.

In ITALY, the surveys, prior to 1873, were carried on by officers of the staff corps under the chief of staff; but then the survey was given a more independent organization under the title of "Military Topographical Institute." Its present director is Major-General de Vecchi.

In SPAIN, the surveys are controlled by the Geographical Statistical Institute, with Major-General Ibañez at its head, and are largely carried on by officers of the army. In 1871 there were about thirty geodetic and topographical parties employed.

In SWITZERLAND, the surveys are under the direction of Colonel Siegfried, chief of staff of the army.

In SWEDEN, the geodetic and topographic survey is carried on by the officers of the general staff of the army. Its head is the chief of the topographical division, at present Colonel von Vegesack.

In RUSSIA, the military topographical corps is charged with surveys. Its organization is: 6 generals; 33 majors, lieutenant-colonels, and colonels; 150 cornets, lieutenants, and captains; 170 classed topographers; 236 topographers, of sergeant's rank; 42 apprentices.

The main divisions of the work of a European state survey are usually three, the triangulation, the topography, and the chartography. When it is practicable, the triangulation precedes the topography, and includes the primary, secondary, and tertiary triangulations and their computations.

If the triangulation points thus determined are numerous, as in the Prussian surveys, additional triangulation by the topographer will not be needed; when, as in Austria, comparatively few points are determined, the topographer will have to base on them a smaller triangulation for his detailed work.

The topographers having been furnished with the positions of certain points within the area to be covered by one of their topographical sheets, make a survey of that area, whose amount of detail will depend on the scale or object of the survey. Their work includes the determination of the required level-curves.

The topographers' sheets go to the chartographic division, whence they are either reproduced on the same scale or reduced to a smaller scale, and the maps resulting from them are published.

METHODS.

It is only within the present century that the methods of geodetic and topographic surveying for large areas have reached high precision. Previously the chief spur to the production of accurate maps was their necessity for military purposes. In some states progress beyond this need has scarcely been made as yet, and the maps give no more detail than is needed for the movement of troops; in others, and notably in Great Britain and Germany, the progress in civilization, the needs of the government, and the dense population have required and have obtained the adoption of systems of topographical survey and publication, which are sufficient for all rational demands.

Aside from the military uses of maps, uses that in Europe must long be among the most important, the increasing intelligence of man in civilized countries demands an accurate knowledge of the earth's surface in his vicinity; a surface that, while slightly modified by his action upon it, yet retains the same principal features from age to age, so that one good survey, with slight occasional corrections, will suffice for an indefinite period.

Where the survey is on a large scale it serves another purpose, by giving, with sufficient accuracy for the imposition of taxes, the areas of all estates, and may, indeed, be made a basis for land-titles. This, however, requires a larger scale than is necessary for ordinary purposes. In England, such maps, called parish plans, are on a scale of $\frac{1}{2500}$. In many European states, cadastral surveys have been made frequently without connection with a topographical survey, their object being the proper apportionment of land-taxes.

Again, when an accurate survey of a country is made, it will aid in the preliminary examinations for works of engineering, such as railroads, canals, river improvements, although no general survey could properly give the detail necessary for the final location or construction of such works.

In nearly all the European states the area over which the survey extends is covered by a net or chains of triangles of large size, the lengths of whose sides vary from 10 to 100 miles, and depend on bases measured with the highest precision that it is practicable to reach; their probable errors not exceeding about $\frac{1}{300000}$ part of their lengths. In some states all the angles of this net are observed with extreme precision, so that the probable error of any angle shall not exceed a few tenths of a second; in others, as in Italy and Spain, certain chains of triangles, 100 or 200 miles apart, running north and south and east and west, thus forming large quadrilaterals, are observed with the greatest precision, the intermediate triangles receiving less care. At the vertices of several of the triangles accurate determinations of latitude and longitude are made, and the azimuth of a triangle side is determined. The heights of the ground above the level of the sea at all vertices are found either by levelings of precision, or trigonometrically. The positions of these vertices are thus accurately known in latitude, longitude, and elevation; they are the precise reference points on which all the inferior points depend.

Starting from the triangle sides of the primary triangulation, the interior of each such triangle is cut up into a smaller triangulation, called secondary, and the secondary triangles, if necessary, into still smaller ones, called tertiary. The vertices of the tertiary triangulation are the guiding points of the topographer; on them he bases his sheets.

Thus, in Austria two or three such points at least are required for every sheet covering $7\frac{1}{2}$ minutes of latitude and 15 of longitude, on a scale of $\frac{1}{25000}$, with one or two additional ones on the sheet, but perhaps outside of the border. This gives one point for each 60 square kilometers, (24 square miles.)

In the Prussian surveys, ten trigonometrical points are required for each fifty-six square kilometers, (22 square miles.) Scale of detail sheets $\frac{1}{25000}$.

In Italy, the scale used being $\frac{1}{50000}$, one trigonometrical point is determined for every 25 square kilometers, (10 square miles.)

The heights of these points are also determined and given to the topographer, who bases on them his level or contour curves.

The determination of points on which the topographical survey depends has now been explained. If possible, those determinations should be made in advance of the topographical work; where that is impracticable, the topographer must leave permanent marks in prominent positions, which are afterward determined from the triangulation.

On the Continent, the topographical work is done mainly with the plane table, the amount of detail introduced depending on the scale adopted. Thus, in Prussia, where the scale of the plane-table sheets is 1 : 25000, all necessary detail can be given. Roads, paths, mills, detached houses, important fences, streams, ponds, forests, bridges, mines—all can be shown. When the scale is diminished to $\frac{1}{50000}$, as in Italy, a part of this detail must be omitted, and still more when the scale of publication is diminished, as in Sweden, to $\frac{1}{100000}$.

In all the best modern surveys, even when hachures are used to give pictorial effect, the relief of the earth's surface is shown by level or contour lines, at elevations differing with the precision of the survey.

In the Prussian sheets, scale $\frac{1}{25000}$, the level curves are 20 or 25 feet apart in elevation. The Swiss sheets, scale $\frac{1}{25000}$, give them 10 meters apart. In the Austrian surveys, at least eight heights are determined in each square kilometer for the scale $\frac{1}{25000}$ and seventeen for the double scale. The level curves are drawn at either 20 or 100 meters apart.

In the publication of the results of surveys, the scale $\frac{1}{25000}$, adopted by Prussia throughout and by Switzerland except for the most mountainous area, appears sufficient for all ordinary purposes. It permits the measurement of distances to within 15 feet. It gives much more detail than the scale of $\frac{1}{63360}$, at first adopted for the British maps; and their map now being published on a scale of 6 inches to the mile, or $\frac{1}{10560}$, while not large enough to give well the boundaries of estates, yet requires about six times as many sheets as the scale $\frac{1}{25000}$ would do.

The scale $\frac{1}{25000}$ furnishes also an admirable basis for detailed geological work, enabling the geologist at once to place on maps of sufficient detail the results of his labor, as is being done in Prussia. Indeed, the general topographical and geological maps of that country now in progress present to us a standard of excellence which can only be attained after many years.

The detailed sheets need combination for general use into maps of a smaller scale. General Dufour adopted $\frac{1}{100000}$ for his excellent map of Switzerland, and the same scale is adopted for the general staff-map of Prussia, derived from the $\frac{1}{25000}$ sheets.

In reference to the cost of these surveys per square mile, save in the case of Prussia, there is little information. In that country there are about 200 square Prussian miles (4,380 square English miles) covered annually by triangulation, costing $78,000, gold. The topography covers the same area per annum, and, with chartography, costs $117,000, gold, per annum. Dividing the total expense, $195,000 gold, by 4,380, we have $44 gold per square mile as the cost of the survey, exclusive of the salaries and allowances of officers. In Switzerland, much of the topography is done by contract, at the rate of 700 or 800 francs per square Stunde, or $16 to $18 gold per square English mile. The cost of triangulation, revision, and publication would have to be added to this. Half the cost of the new Swiss survey is borne by the confederation and half by the cantons.

Publication on the scale of the field-sheets only takes place when some society or person agrees to bear half the expense. Austria expends annually about $490,000 for her surveys, but the area covered is not known. It is stated that in the Austrian surveys an officer experienced in topography can, with the aid of two or more soldiers, survey in the six summer-months, on a $\frac{1}{25000}$ scale, from 350 to 500 square kilometers, (140 to 190 square miles,) drawing the same in colors during the winter.

Schiavoni, in Principii di Geodesia, states that a topographer in six months can complete 81 square kilometers, the scale being $\frac{1}{20000}$. The wide difference in these estimates is doubtless due in part to difference in precision of the work, although the scales are nearly the same.

A writer in the North American Review of July, 1875, estimates the total cost of the ordnance-survey of Great Britain up to that date at about $20,000,000, in gold, and the area at 111,000 square miles. This would give a cost of $190 per square mile, the work not yet being complete. It should be remembered that it includes many publications on scales larger than $\frac{1}{25000}$.

Taking the Prussian survey as a model and recollecting that the cost,

$44 per square mile, previously stated, does not include the pay of officers, nor (probably) the cost of the Geodetic Institute, which has charge of the primary triangulation and astronomical work, these two omissions, perhaps, increasing the cost of the work to $60 or $65, it is very doubtful if similar work in this country, on account of the greater cost of labor, both skilled and unskilled, could be done for less than $100 gold per square mile.

If a lower standard of accuracy were adopted, such as determination of but one triangulation-point in 25 or 50 square miles, level curves 100 feet apart, field-sheets on a scale of $\frac{1}{50000}$, and published maps on a scale of $\frac{1}{100000}$, the cost might perhaps be reduced to $50 gold per square mile. For level, thickly-settled areas, with numerous telegraph-lines, the cost of the first and less precise maps might be further reduced by substituting astronomical for trigonometrical determinations of the guiding-points. But when at last good topographical work was to be done, trigonometrical points would still be necessary.

Since the General Government, for military and administrative reasons, is interested in these surveys, it should bear a part of the expense. That part might well be the execution of the triangulation for any State that was prepared to make a topographical survey. A triangulation, giving points not more than five or ten miles apart, whose positions were accurately known and permanently marked, would establish firm bases on which all future topography carried on by the States would safely rest. If any town or county desired greater precision in its topography than that adopted as a general rule for the State, the greater precision should be given upon its paying one-half the additional cost. When, at any subsequent time, a given locality desired a new and better map, a resurvey, based on the same permanent trigonometrical points, could be made without being affected by the inaccuracies of the neighboring surveys, no errors being propagated beyond the nearest of those points.

Such a plan would involve no large errors, even when the topographical survey was inferior; it would admit of indefinite increase in precision of detail for any locality, as towns or counties desired that increase and were prepared to meet the expense.

The advantage of placing the triangulation in the hands of the General Government is that its execution would be systematic and precise, avoiding the confusion of methods and uncertainty of accurate results inevitable if there were as many heads concerned in it as there are States in the Union, each largely controlled in his methods by the varying liberality or parsimony of State appropriations.

The triangulation, if once well done, is done forever, and it is more economical not to do it at all than to do it badly.

In its execution, equal precision in the measurement of all the primary triangles would be unnecessary. Chains several hundred miles apart, running along meridians and parallels, (except when they followed mountain-ridges or sea-coasts,) should have their angles measured with the highest precision, so that their results might be available for determining the dimensions of the earth. The interior of the huge quadrilaterals thus formed would be covered with triangles measured with an accuracy less, but still ample for all mapping purposes.

Such a plan, giving, at once, final accuracy in the controlling points and permitting indefinite increase in the representation of the detail around them, furnishing a skeleton to which all local surveys could be fitted, till the whole was complete, would at least supply us with maps

of our country that would be creditable and that could be compared with those of other civilized nations.

Only the richer and more thickly-settled States could undertake the topographical survey at present; its extension over the United States would require a century.

Very respectfully, your obedient servant,

C. B. COMSTOCK,
Major of Engineers and Bvt. Brig. Gen.

Brig. Gen. A. A. HUMPHREYS,
Chief of Engineers, U. S. A.

CHAPTER II.

§ 1.—The Ordnance-survey of England.

METHODS.

Base-lines are measured with the Colby compensation-bars. The compensation-bar consists of two bars, one iron, the other brass, each 121″.5 long, 0″.5 broad, 1″.5 deep, laid parallel to each other 1″.125 apart and firmly connected at their center by two small transverse steel cylinders. At each extremity of the bars is a metal tongue, 6″.2 long, so connected by pivots to the bars as to admit freely of any expansion or contraction and yet be quite immovable otherwise. On a silver pin at the extremity of each tongue are marked the compensation-points. This compound bar is inclosed in a box, from which project the tongues carrying the compensation-points.

The complete set consists of 6 bars. The interval between the adjacent compensation-points of two bars lying in line for measuring is brought to exactly six inches by means of a compensation-microscope.

Primary triangulation is executed with theodolites having 36, 24, or 18 inch horizontal limbs, divided by dots into spaces of 10′ and provided with micrometer-microscopes for reading.

By means of a secondary triangulation the principal triangles, having sides 20 to 60 miles long, are subdivided into triangles having sides about 5 miles long. This work is done with a 12-inch theodolite.

By the parish or tertiary triangulation the 5-mile sides of the secondary work are subdivided by a net-work having sides of about one mile. In this work a 7-inch theodolite is used.

The detail-work, called field-surveying, is based upon the tertiary triangulation, and in it all boundaries of counties, parishes, townships, and boroughs, roads, canals, streams, fences, houses, divisions between cultivated and uncultivated land, the edges of ravines and precipices, and the outline of masses of outcropping rock are located.

In the cultivated districts the detail-surveying is done with the chain alone. The sides of the tertiary triangles, the lengths of which have been determined by computation, are chained, and the triangles are subdivided by chained lines from which the details to be located are fixed by intersection with the chained lines or by offsets from them. Traversing with a 5-inch theodolite is used, but only when the surveying by right lines would be attended with complication and difficulty, as in the case of a crooked river, at the bottom of a ravine, or in surveying paths or other details through a wood.

In the uncultivated and wooded districts and in the highlands, the surveying is principally performed by traverse or by a combination of traverses and right lines depending on them. The district is divided into blocks bounded by roads, rivers, or county-lines, and general lines of traverse are run starting from trigonometrical stations so as to embrace a whole block and close on the starting-point, thus checking both the azimuth and distance. The general lines of traverse are also connected with every convenient trigonometrical station by a closing angle and distance, and from all trigonometrical stations closed on, when practicable, angles are taken to at least three surrounding stations and

to one or more conspicuous permanent objects between them. Intermediate or cross-traverses are then proceeded with, starting from and closing on previously established pickets of other traverses on the same meridian, the angle of the former station being always retaken at closing; and in case of more subsidiary traverses made for fixing isolated objects some check-tie is given, such as a return-distance to some other picket on the traverse started from.

In surveying by chained lines the field-party consists of 1 surveyor and 1 chainman; in surveying by traverse, of 1 surveyor and 2 laborers. It is customary to form surveying sections of from 8 to 12 surveyors, in charge of a non-commissioned officer, whose duties are to issue the printed forms of notice, extracts from the acts of Parliament, to the owners of property and others, of the intention to enter upon their lands for the purposes of the survey; to lay down a standard length on a suitable level spot from the standard-chain with which he is supplied, and to parcel out the triangles to the several surveyors; to visit the surveyors in the field and test the accuracy of their work. The surveyors' note-books are regularly inspected by the superintendent to see that the work is properly closed, the diagrams kept up, and all references supplied. All notes are kept in ink, no interlineations of figures or erasures with a knife are permitted, and all alterations in the notes must be supported by the initials of the surveyor.

The plans of the populous, cultivated, and mineral districts are drawn upon the scale of $\frac{1}{2500}$; the highlands and other partially-cultivated and thinly-peopled districts on the scale of 6 inches to 1 mile.

The notes and diagrams of field-surveys are sent to the office to be plotted and checked by the triangulation; when the discrepancy in chain-work exceeds 1 in 500 the diagram is returned to the superintendent in the field for correction by resurvey. The surveyors are paid by the piece, so much per acre, and all resurveys and corrections must be made at the expense of the surveyor.

After the work is plotted and checked a tracing is made for examination on the ground. The examiner is required to verify the work by judicious intersections, so that the different portions of detail shall mutually prove each other; he fixes the location of trees, footpaths, and all other ornament, supplies the names of hills, streams, houses, and bridges, and collects much of the detailed information given on the ordnance-survey maps.

The traces, having been scrutinized and approved by the examiner, are given to the draughtsman, who transfers all the detail and corrections to the original and then pens in the outline and detail. Types for letters and figures and a variety of stamps for trees, woods, and different characters of ground are used to expedite the work of the draughtsman.

The plans, as they are completed, are subjected to a close office-scrutiny by a competent examiner, who compares the plan with the tracing and sees that the plans are accurately drawn in every respect.

A personal examination of the plans on the ground is made by the officer in charge at this stage, after which they are forwarded by groups to the officer in charge of the leveling, to have the levels inserted, and they are subsequently examined with all the documents complete at the office at Southampton.

Leveling.—The general mean level of the sea for England was obtained by tidal observations at 32 different stations. The means found at each station were connected by leveling and referred to the datum-plane, the height of mean tide at Liverpool. In this primary leveling

a series of levels were established along the principal routes of communication through the interior of the country, to serve as a basis for subsequent leveling operations of a more detailed kind, called secondary leveling, which provides, by the leveling and contouring operations, about 1 linear mile of leveling to every square mile, establishes bench-marks and contours for every 100 feet of altitude, up to 1,000 feet above the sea, and determines the height of every trigonometrical station. In the primary leveling the accuracy of the work was checked by again leveling each line backward. In the secondary leveling, the work is checked by closing on the primary work. The limit of closing error is 0.01 foot per mile in long lines. The relative altitude of two stations is determined by measuring the angle of elevation from one station to another by reciprocal zenith-distances or by the usual operations of spirit-leveling.

Contouring.—For this work a 5-inch theodolite is used, and contour-lines are traced on the ground and marked with pickets. The leveler runs a level line from a bench-mark near the required altitude until the contour to be traced is found; then the rodman, with his target set to the height of the instrument, moves along the contour-line as directed by the leveler and marks the points determined with pickets.

When a sufficient length of the contour is marked, the contourer makes a survey of it, plotting his work on a projection furnished him as he proceeds on the ground. This work is verified by an examiner, who again traces the contour and verifies or corrects its location by running the line in the opposite direction.

Hill-sketching.—The object of this work is to produce delineations of the form and relative altitude of the ground, to be used as data in the brush-work studies required for the guidance of the hill-engraver. The sketcher is furnished with a projection, on which the contours are traced, scale 6 inches to 1 mile, a prismatic compass, protractor, and scales for hill-sketching. Points are located for intermediate contours by bearings; distances are determined by pacing. In sketching, the horizontal system is used for slopes less than 45° and the vertical system for slopes greater than 45°. The work of the hill-sketcher is examined and verified by an officer on the ground, and the sheets are then given to the draughtsman for reduction to the scale of 1 inch to 1 mile. In the reduction, the hill-sketches are made in India ink with a brush. When complete, this reduction is given to the engraver.

Photographic reductions.—The ordnance survey-plans, scale $\frac{1}{2500}$, are reduced to the scale of 6 inches to 1 mile by photography, and silver prints of the reductions are used by the copper-plate-engraver.

Plans to be reduced by photography are prepared with that view. Lines are made somewhat thick, and are drawn in rich black ink; houses are tinted red; waters, blue; roads are left uncolored. A camera, with plate $16\frac{1}{4}$ inches square, and Dullmeyer lens 3 inches diameter, 24 inches focus, is used. This gives a field of the size of the plate, with good definition over the whole of it, with practically no distortion. The plan is mounted on a stand properly adjusted with respect to the camera, and its image is made to cover a figure on the glass equal and similar to that formed by the marginal lines of the plan drawn on the scale to which it is to be reduced. Proper adjustments are provided to secure the required position of the plan and camera. Plate-glass is used for the sensitized wet collodion-plate; and it is mounted so that the collodion-film can be made to take the exact place occupied by the ground-face of the focusing-glass. The negatives and prints are produced by the usual methods.

Photographic views published in connection with the ordnance-surveys have been produced by the use of dry plates prepared by the Tannier process. Many plates prepared in this manner have been used after six months with good results. Fair results have been obtained with dry plates four years after their preparation. The exposure required is about four times that necessary for a wet plate. The plates have been kept more than a month between exposure and development without any trace of deterioration.

Engraving.—The 6-inch maps are engraved on copper plates 36 × 24 inches.

The corners of the sheet and the trigonometrical points are first pricked on the copper plate by a scoring-machine, furnished with graduated scales read by verniers. The plate is then removed from the scoring-machine and placed on an iron table heated by gas, while a wax-ground is laid upon it. When this has been done, the corresponding points on the margin are joined with fine ruled lines, by which the sheet is divided into sixteen equal rectangles. Tracings of the photographs to be engraved are made with lamp-black, and each, being a sixteenth part of the 6-inch sheet, fits into one of the rectangles drawn on the copper plate, and is transferred to the wax-ground by rubbing with a steel burnisher, after which the plate goes into the hands of the engraver. The outline is first engraved, and then the writing, afterwards the ornament, rocks, woods, water, and contours. Figures are punched with steel type; trees and woods, with steel punches. Parks and sand are ruled with a dotting-wheel; buildings are shaded with a ruling-machine. Hills are engraved, on the 1-inch sheets, by etching with acid. Four proofs are taken at different stages of the work, and each proof is examined and all corrections are made before the sheet is pronounced ready for publication.

Electrotyping.—This process is applied for several purposes:

I. Duplicates of the original engraved plates are obtained, thus saving them from being worn out by constant printing.

II. Alterations can be made in the cast or matrix, in which the details are in relief, much easier than by cutting out from the original plate.

III. Parts of several engraved plates may be used to form a single plate for printing from.

IV. Copies are taken of the engraved plates in different stages of their progress and with different classes of information engraved upon the different copies. Thus the 1-inch map of Great Britain is published in outline with contours, another with hills complete but without contours, a third with the geology engraved, &c.

In producing the electrotype-plates a Smee battery, single cell, is used; zinc plates 2′ × 2′ 4″, silvered copper plates $4\frac{1}{2}$″ wide, six of them being placed together in a frame presenting a surface equal to that of the zinc plate. With this battery $\frac{1}{3}$ of a pound of copper to one square foot of surface may be deposited in 24 hours.

The engraved plate is washed with cyanide of silver, and afterward with a solution of iodine in alcohol, and then exposed to the sun. A composition of wax and tallow is laid around the plate to prevent deposit on the edge. The plate is then put in the electrotyping-cell and a sheet of copper larger than the plate is laid over it and separated from it by 1 inch. The wires are attached, the matrix is produced, and a duplicate is obtained from the matrix by the usual process. The duplicate is next hardened and finished and may then be used for printing.

Zincographie printing.—In this process zinc plates $\frac{3}{16}$ of an inch thick

are used. The plate is prepared by scraping it evenly until all irregularities and other defects are removed, is then ground with pumice-stone and water, and smoothed with a piece of steatite. A grained surface is given to the plate by rubbing over it molding-sand and water with a zinc muller. The plan to be zincographed is traced in lithographic writing-ink on tracing-paper thinly coated with starch. The tracing is put for a few minutes in a dampening-book moistened with water and nitric acid to neutralize the alkali in the soap of the ink. Next, the tracing is put between sheets of paper moist with water only, and is left to expand to an extent equal to the amount of contraction which will take place in the wet paper on which the maps are printed, about $\frac{1}{4}$ of an inch in 3 feet. The damp tracing is laid face downward on the prepared surface of the zinc plate, a sheet of paper is placed over it, and the whole is passed through the lithographic press several times. The covering-paper is removed, the tracing is dampened and carefully peeled off the surface of the zinc. The outline will be found on the zinc in ink, which the starch has prevented from soaking into the paper. The face of the zinc plate is now washed with hard water and a sponge to remove the starch, and is then etched with a preparation of phosphoric acid to remove dirt and finger-marks and give a slight relief to the parts protected by ink. A roller, charged with lithographic printing-ink, is next passed over the zinc plate, which is kept moist with a wet cloth. The ink only adheres to the parts where the writing-ink has been absorbed. The plate is now ready for use in printing.

The zincographed impressions are colored; water, blue; buildings, carmine; roads, raw sienna.

Photozincography.—In this process a negative of the plan or map to be reproduced is taken on a glass plate and the silver deposit is blackened with corrosive sublimate and ammonium hydrosulphate; a sun-print is taken from the negative on paper, coated with gelatine and bichromate of potassa, which surface, when exposed to the influence of light, is insoluble in water at a moderately high temperature.

The print is uniformly covered with greasy transfer-ink, and afterward washed with warm water, to dissolve the gelatine unacted upon by light, and so carry away the ink upon it, which will now remain only on the insoluble portions. In this way a print in a greasy carbon-ink is prepared, which can be transferred to zinc or stone in the usual manner. The paper used for the carbon-print should be tough, and have a surface that will remain almost undisturbed when saturated with water.

Anastatic process.—By this process a direct transfer is made from a printed impression to a zinc plate, which is then used for printing. Fresh prints, not dry and hard, may be transferred as follows: The face of the print to be copied is laid upon clean blotting-paper and the back is brushed over with nitric acid diluted with water. The print is then deprived of superfluous moisture by pressure between sheets of blotting-paper, is placed faced downward on a prepared zinc surface and passed through the printing-press. On removing the print the zinc plate is sponged over with gum-arabic, water is added, and the plate is gently washed. The transfer is then charged up with lithographic printing-ink, washed with water, and etched with phosphoric acid and gum-water, and is then ready for use in printing. Alterations may be made by obliteration with steatite, polishing with emery-cloth, and transfer as before. If additions are required, the polished surface is acted on by nitric acid and water, and then the additions can be made with a pen and transfer-ink and be etched as before described.

Old prints, dry and hard, are first softened for transfer by immersion in hot water to which caustic strontia has been added.

Authority.—Methods and Processes of Ordnance Survey, 1875.

Compiled by H. M. Adams, Captain of Engineers.

§ 2. The Ordnance Survey of Great Britain.

ORGANIZATION AND MAPS.

The data available for this report are the "Report of the Progress of the Ordnance Survey to 31st of December, 1874," and 36 atlas-sheets, which are samples of the various scales employed and of the different styles of publication.

ORGANIZATION.

The following facts appear from the report. The ordnance-survey forms a part of the work of the Royal Engineer Corps, and the present director-general is Lieutenant-General Sir Henry James, R. E. An officer of the Royal Engineers has charge of each of the different divisions of the survey. The areas over which the surveys are being made are divided into districts comprising one or more counties, and the work in each district is under the immediate charge of an officer of engineers stationed in the district.

At the date of the report there were employed upon the survey 19 officers of the Royal Engineers; 4 companies of engineers, consisting of 121 non-commissioned officers, 243 sappers, and 8 buglers; 1,000 civil assistants of different grades, and 448 laborers.

SCALES EMPLOYED AND METHODS OF PUBLICATION.

Numerous scales are adopted for the survey and publication, in order to meet the requirements of the public and of the various departments of the government. The scales employed for the general maps of the country are those of one inch and six inches to the mile, ($\frac{1}{63360}$ and $\frac{1}{10560}$,) and the plans of the whole United Kingdom are being engraved on copper on these scales.

For the purposes of the valuation of property, the survey of all the cultivated parts of England, Scotland, and Wales is made on the scale of $\frac{1}{2500}$, or 25.344 inches to the mile, commonly called the inch-to-the-acre scale. The plans on this scale are called parish-plans, and are made by photozincography, a process discovered by the director-general in 1860. These plans are reduced by photography for publication on the 6-inch scale.

The principal scales adopted for the plans of cities and towns are that of $\frac{1}{500}$, or 10.56 feet to the mile, for towns of over 4,000 inhabitants, and that of $\frac{1}{1056}$, or 5 feet to the mile, for smaller towns, although the plans of a few towns have been surveyed and drawn on scales of 1 foot, 2 feet, and 20 inches to the mile. These plans are either engraved or zincographed. In addition to the above-mentioned general maps and plans, special plans, as required, are made for the use of the governmental departments, the courts, &c., and the expenses incurred in their preparation are re-imbursed to the survey.

Geological lines and references have been engraved on some of the 6-inch and 1-inch sheets. None of these, however, are contained among the sample-sheets.

The various publications are sold to the general public at moderate prices. The receipts from these sales for the year 1874 amounted to over £8,000.

STATE OF THE SURVEY AND PUBLICATION AT THE CLOSE OF THE YEAR 1874.

England and Wales.—Area, 58,000 square miles. Surveyed on the 6-inch and $\frac{1}{2500}$ scales 26,358 square miles. Surveyed during the year 1874 1,456 square miles. Published on the $\frac{1}{2500}$ scale 11,527 square miles, and the 6-inch scale 16,678 square miles. On the 1-inch scale the whole map was completed and published, constituting what is called the old series. A new series of maps on the 1-inch scale on an improved projection and with a more uniform system of numbering of the sheets is now in course of publication. Plans of 95 towns on the $\frac{1}{500}$ scale and of 61 towns on the 5-foot scale, had been published, and those of 19 towns had been surveyed and drawn, but not engraved on the $\frac{1}{500}$ scale.

Scotland.—Area, 30,000 square miles. Surveyed on the 6-inch and $\frac{1}{2500}$ scales 28,858 square miles, of which 1,029 square miles were surveyed during the year 1874. Published on the $\frac{1}{2500}$ scale 10,908 square miles; on the 6-inch scale, 19,850 square miles; and on the 1-inch scale, 14,394 square miles. The surveys of the towns of Scotland were completed, and the plans of 45 towns on the $\frac{1}{500}$ scale and of 15 towns on the 5-foot scale had been published.

Ireland.—Area, 32,813 square miles. The survey on the 6-inch scale had been completed and the map published. The maps of ten counties had been revised and new editions of them published. The whole map on the 1-inch scale had been engraved and published in outline, and the engraving of the hills was in progress. The area published with the hills is 16,694 square miles. Plans of 74 towns on the 5-foot scale, of 1 on the 2-foot scale, of 14 on the 20-inch scale, and of 12 on the 1-foot scale had been drawn, but not published. Plans of 8 towns on the $\frac{1}{500}$ scale had been surveyed, but not drawn.

DESCRIPTION OF THE MAPS AND PLANS.

The following details respecting the maps and plans are obtained from an examination of the 36 specimen-sheets and from the index-sheets published in the report for 1874.

One-inch scale.—The old series of the map of England on this scale is published in two styles, which differ only in the manner of representing the relief, which is indicated in the one by level curves and in the other by hachures. Each sheet represents an area of 26′ 50″ in longitude (about 18 miles) by 10′ 25″ in latitude, (about 12 miles.) The projection-lines do not extend across the sheets on any of the ordnance-survey maps. On the sheets of the 1-inch scale the border is divided into 10″ spaces. The maps contain a great deal of detail, the topographical features being indicated by the usual conventional signs. They show the rivers, streams, lakes, marshes, mountains, valleys, moors, forests, villages, isolated houses, triangulation-stations, (with their altitudes,) railroads, turnpikes, common roads, ruins, ancient settlements, boundary-lines of counties, townships, and parishes.

The nomenclature is very detailed, the names of isolated houses or of their owners and the local names of hills and other accidents of the

ground being given. The level curves are 100, 250, or 500 feet apart, according to the nature of the surface.

There are no sheets of the new series of the 1-inch map of England with the samples sent, but the index-map shows that the new map will consist of 360 sheets, each representing an area of 18 by 12 miles.

The map of Ireland consists of 205 sheets, which only differ from those of the map of England in having on the margin of each two diagrams, the one an index to the 6-inch maps on the sheet, and the other showing the numbers of the eight adjoining sheets of the 1-inch map.

The map of Scotland and the neighboring islands will consist of 131 sheets. The sheets are larger than those of the corresponding maps of England and Ireland, each representing an area of 24 by 18 miles, but in other respects they are entirely similar to those of the map of Ireland.

Six-inch scale.—The sheets on this scale appear to be numbered by counties. Each sheet represents an area 6 by 4 miles. The latitude and longitude are shown on the border, which is divided into 1″ spaces. Four scales are given, viz, of feet, miles, chains, and perches. The numbers of the adjoining sheets are indicated by letters on the margin at each side. In addition to the features shown on the 1-inch map, upon this appear all houses, barns, outbuildings, &c., with their correct outlines, wells, fences, hedges, bridges, telegraph-lines, &c. The areas of the townships and parishes of Great Britain and of the town-lands of Ireland are engraved upon the sheets.

The relief is shown both by level curves at distances of 25, 50, or 100 feet apart, according to the nature of the ground, and by figures placed on the roads giving the altitudes for about each 1,000 feet of distance, and also by figures giving the altitudes of bench-marks made on walls, buildings, &c.

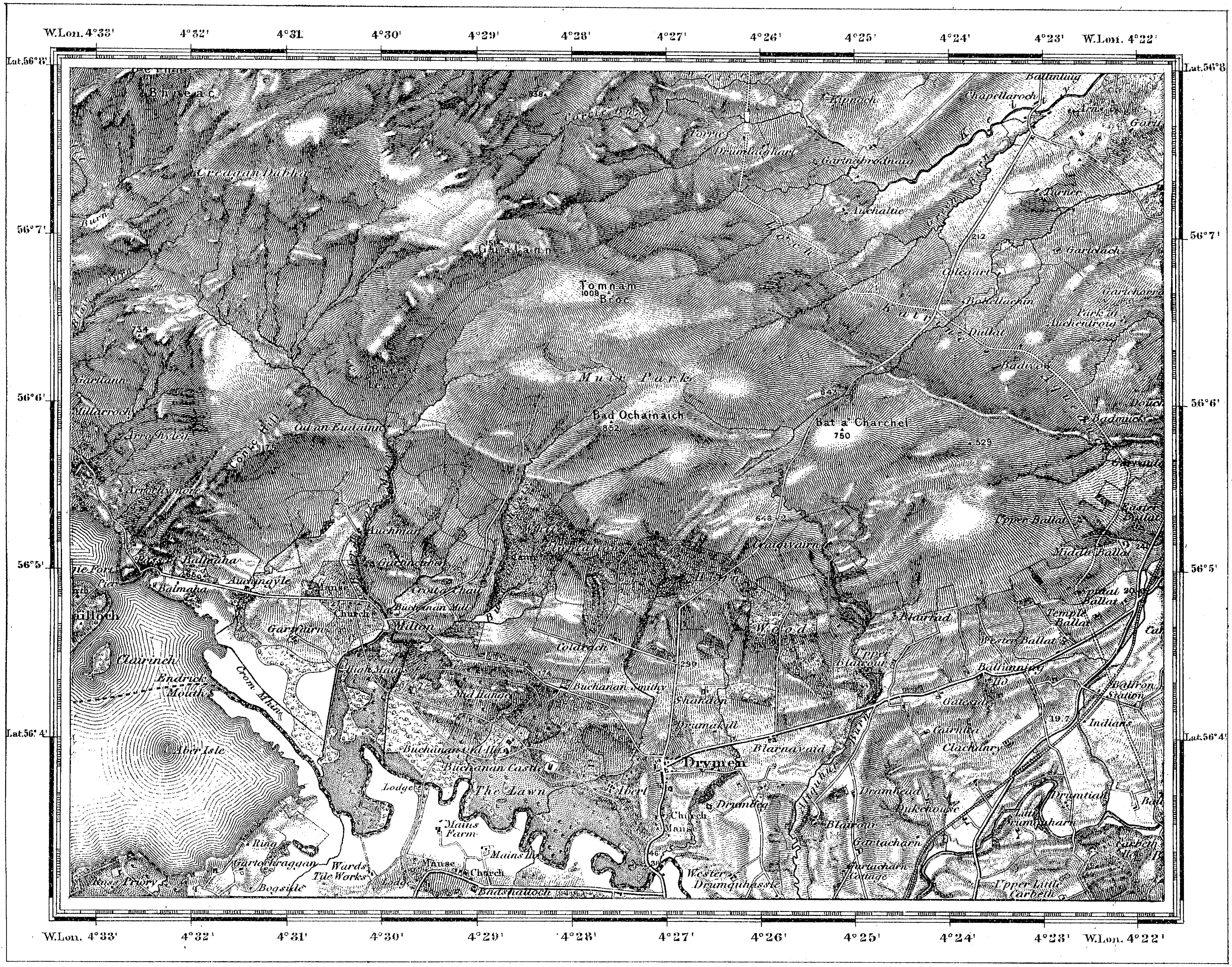
The names of roads, of the principal streets and buildings in the cities and towns, of bridges, (the materials of which they are constructed, whether wooden, iron, or stone, being also stated,) of farms, parks, woods, hills, detached houses, &c., are given with great minuteness.

$\frac{1}{2500}$ *or* 25.344*-inch scale.*—Each sheet represents an area of $1\frac{1}{2}$ by 1 miles. The numbers of the adjoining sheet are shown by the method used in the 6-inch maps. Scales of miles, chains, feet, and in some cases of links and yards are given. Latitudes and longitudes are not indicated. These plans contain essentially the same natural and artificial features as the 6-inch maps, but the amount of detail is of course greater, the scale being sufficiently large to admit of the accurate location of individual trees, &c. Each subdivision of the land is numbered, the numbers referring to corresponding numbers in area-books which are published in connection with the plans. There are no level curves, the relief being indicated by numbers giving the altitudes of points at short distances apart on the roads, and by the heights of bench-marks. These plans are published both plain and in colors.

$\frac{1}{1056}$ *or 5-foot scale.*—Each sheet represents an area of 3,170 by 2,120 feet. Scales of feet and links are given. The numbers of the adjoining sheets are shown on the margin, which also contains a diagram indicating the position of the sheet on the $\frac{1}{2500}$ maps. These sheets are detailed plans of the cities and towns for which they are made, containing accurate representations of the outlines of buildings, streets, railroads, parks, &c., and the positions of fire-plugs, lamp-posts, &c. The names of public buildings, churches, (with the number of their sittings,) hotels, manufacturing establishments, and other large buildings are given. The relief is indicated in the same manner as on the sheets of the $\frac{1}{2500}$ scale. The plans are issued both plain and in colors.

ORDNANCE SURVEY of SCOTLAND

PART OF—SHEET 38



Scale, 1: 63360.

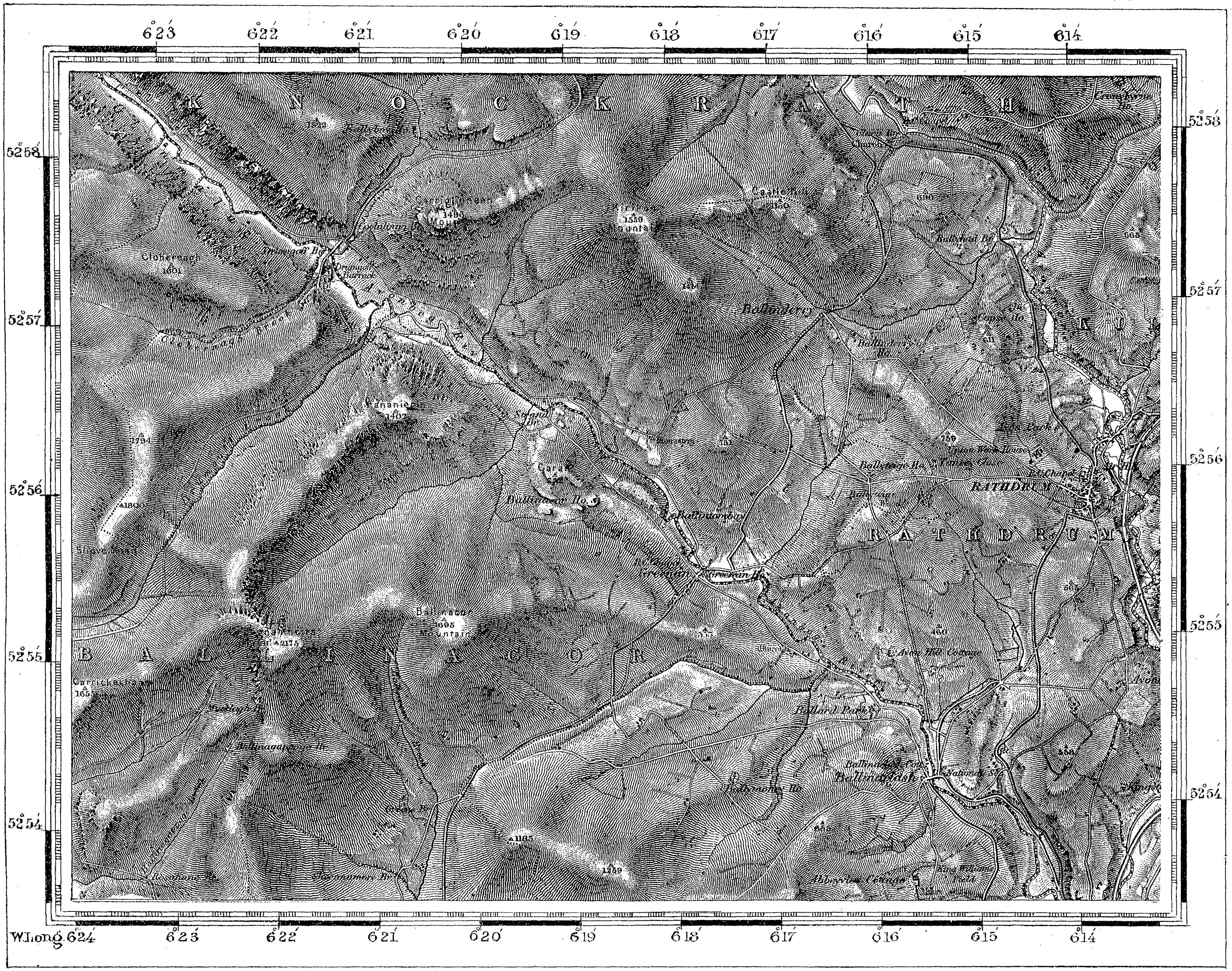
8 7 6 5 4 3 2 1 0 — 1 — 2 — 3 — 4 Miles

No.s of the adjoining Sheets of the One Inch Map.

45	46	47
37	38	39
29	30	31

ORDNANCE SURVEY OF IRELAND

Part of SHEET 130.



Scale $\frac{1}{63360}$

Nos. of the adjoining Sheets of the One Inch Map

120	121	
129	130	
138	139	

$\frac{1}{500}$ *or* 10.56-*foot scale.*—Each sheet represents an area of 1,600 by 1,060 feet. Scales of feet and links are given. These plans appear to contain about the same features as the 5-foot plans, the only difference being that the larger scale shows more clearly the various details represented, and admits of a more minute naming of the different buildings, &c. The two specimens of these plans are both colored.

Authorities.—Ordnance Survey Report 1874, and 36 maps.

Compiled by Lieut. P. M. Price, United States Engineers.

CHAPTER III.

§ 1. Notes on Prussian Surveys.

In 1864 the survey of the six eastern provinces of Prussia was undertaken, their total area being about 4,200 square Prussian miles, (one Prussian equals 4.68 English miles.)

The time then estimated for the completion of the work was ten years, but the plan was subsequently extended to include the whole state.

The geodetic and astronomical work is under the charge of General J. J. Baeyer, who directs the Geodetic Institute and the central bureau for the European measurement of degrees, (*Gradmessung.*)

The trigonometrical, topographical, and chartographic operations are under the general staff of the army, the present head of the land-survey being General Von Morozowicz.

The aim of the triangulation is to furnish for all time a net that shall be accurate enough for any demands that may be made upon it, even if surveys should be desired on a scale so large as $\frac{1}{2000}$. The sides of the small triangles furnish bases for detailed topographical work.

The triangulation of the first class consists of chains of large triangles running through the area to be surveyed. Its angles are measured with theodolites having circles not less than 10 inches in diameter by twenty-four pointings at each object. Objects are pointed at in the order A, B, C, D—D, C, B, A, and between each such set of pointings the horizontal limb is turned 30° in azimuth. The probable error of any triangle side must not exceed 1 : 100000.

In the triangulation of the second class the triangle sides usually vary between 1½ and 2 Prussian miles in length. The angles are read with 8-inch theodolites, giving seconds, twelve pointings being obtained on each object. The probable error in the lengths of the triangle sides must not not exceed 1 : 50000.

The detail triangulation (of third and fourth classes) is based on the triangulation of the second class. It must give nine or ten points at least in each Prussian square mile, (equals 22 English square miles.) The angles are read by 5-inch theodolites, giving seconds, and the probable errors of its sides must not exceed 1 : 25000.

The triangulation of the first and second classes consists of chains; that of the third and fourth classes must, if possible, be a continuous net, covering the whole area to be surveyed.

The angles of the triangulations of the first and second classes are adjusted by Bessel's method.

The heights of all triangle points are determined by a combination of ordinary and trigonometric leveling.

All triangulation points are marked by cut stones.

The processes of triangulation have now been described. The maps resulting from the work are of two classes: 1. Those on the scale of 1 : 25000, which are reproductions of the original plane-table sheets on the scale 1 : 25000; each of these plane-table sheets covers the area included by two meridians 10 minutes apart and two parallels 6 minutes apart. 2. Maps on a scale of 1 : 100000, covering an area of 15 minutes in latitude by 30 minutes in longitude, are derived from the 1 : 25000 maps.

The topographical work consists in the production of finished plane-table sheets on a scale of 1 : 25000, and is based on the nine or ten trigonometrical points determined in each Prussian square mile. As one of the sheets covers an area of $2\frac{1}{4}$ such miles, it has on it about twenty such points.

These trigonometrical points are plotted on Whatman's paper, which is fastened by its whole under surface to a plane-table with white of egg. The alidade of the plane-table has a vertical circle and stadia wires, so that with a stadia distances and elevations are readily determined. While for the important points prosections and resections and the three-point problem are used for fixing points on this plane-table sheet, much of the work is done with the stadia.

For important points the plane-table is oriented only on other well-determined points. In less important work, in a country free from local attraction of the magnetic needle, this is used for orientation.

All roads, streams, bodies of water, streets, isolated houses, forests, tax-boundaries, hedges, gardens, terraces, and, generally, all objects either important in themselves or in a military point of view are represented that the $\frac{1}{25000}$ scale will express. For many smaller objects conventional signs are established. Woods are classed and represented as leafy, needle-leaved, (coniferal,) and mixed.

It is assumed that in general, even in broken ground, a sufficiently accurate representation may be obtained when the stadia-points have an average distance from each other of about 200 meters. Intermediate details are sketched on the plane-table without use of the alidade, by setting the table up approximately at each stadia-point and by pacing. The permissable limits of error in distances on the plane-table sheet of any point are from 10 to 20 meters, and in elevation from 1 to 2 meters.

The ordinary difference of elevation of contour curves is 5 meters, but when, for military purposes, more detail is needed, curves $2^{m}.50$ or $1^{m}.25$ apart may be used. Curves of 5 meters and less are represented by broken lines, of 10 meters by a full line, and of 20 meters by a heavy line. Their heights are given from the sea-level.

Much of the plane-table sheet is inked in the field; but parts which are common to another sheet are not inked until after a comparison with that sheet is made in the office. The sheet is then completed and illuminated for photographic reproduction. This illumination consists in applying pale tints of color, seven in number, to certain parts of the plane-table sheet, so as to give more prominence to water, roads, stone, buildings, court-yards, forests, marshes, &c. On these sheets relief is given by contour lines. On certain rough copies of them, for military use, the tintings of color are stronger, and hachures may be added to the contour lines. For a scale of $\frac{1}{25000}$, when hachures are used, there are 40 in 3 centimeters. They express every 5 degrees of slope from 0° to 45°, and the ratio of the width of the black line to its white interspace, when $x°$ represents the slope, is $\frac{x°}{45°-x°}$

Lehmann's method of representing slopes uses only full straight lines for hachures. In General Maffling's modification some of these lines are broken and some waving.

On the $\frac{1}{100000}$ maps Maffling's system is used for slopes of 5° and 10°, and Lehmann's for greater ones.

General Bæyer has proposed to replace the plane-table for all precise topographical work by the theodolite and stadia; and this has been done, partially or completely, in the cadastral survey of Schwarzburg-Sonderhausen.

Oberforstmeister Michaelis states that the accuracy was largely increased without increase of cost over that of graphical work. Theodolites have also been used in the surveys in Wurtemburg and Gotha for topographical work; but the plane-table is still in general use.

Two hundred square Prussian miles are covered annually by triangulation and topography.

For 1875, excluding salaries of officers and soldiers, the expense of triangulation was 312,000 marks, and of topography and chartography 470,000 marks; one mark being about 24 cents gold.

In 1874 the cost of the Geodetic Institute was 106,440 marks.

Authorities.—Manuscript letter of Lieutenant General von Morozowicz, chief of land survey, of June 16, 1876, to Count von Moltke; Die preussische Landes-Triangulation; Umgegend von Berlin, Berlin, 1867; instruction für die Topographen der königlich-preussischen Landes-Aufnahme, Heft I. und II., Major Baumann, Berlin, 1876; Letter of Count von Bulow of December 2. 1875.

Compiled by Major C. B. COMSTOCK, Corps of Engineers.

§ 2. NOTES ON PRUSSIAN MAPS.

ORGANIZATION OF THE SURVEY.

From the letter of Herr Von Bulow to the chargé d'affaires of the United States at Berlin, dated December 2, 1875, a copy of which has been furnished, it appears that the several branches of the public surveys are in charge of different departments of the Government, as follows:

TRIGONOMETRICAL, TOPOGRAPHICAL, AND CHARTOGRAPHICAL WORK.

This work is entrusted to the general staff of the army.

The trigonometrical department triangulates annually over an area of 200 square Prussian miles, establishing ten points, marked by stones, to the square Prussian mile. (1 Prussian mile is equal to 4.68 English miles; 200 square Prussian miles are equal to 4,380.48 square English miles.) Its personnel is: 1 chief, 6 measurement-directors, (staff officers or captains,) 8 detailed officers, (lieutenants,) 18 upper gunners, (assistant observers.) Besides these there are the necessary office and house personnel.

The cost of the trigonometrical measurements for 1875, exclusive of the salaries and allowances of the officers, was 312,000 marks, (about $78,000 gold.)

The topographical department surveys annually 200 square Prussian miles on the scale of 1:25000, establishing also the level-curves. It also perfects the earlier surveys by annual reconnaissances. The personnel is: 1 chief, 5 measurement-directors, (staff officers or captains,) 20 detailed officers, 10 engineer-geographers, 70 assistant topographers, (upper gunners, gunners, and civil assistants.)

The chartographical department has charge of the publication of the maps both on the original or 1:25000 scale and on the 1:100000 scale, (the so-called general-staff chart.) The published sheets can be purchased through the book-stores. The personnel is: 1 chief, 1 officer, (staff officer or captain,) 1 technical inspector, 11 draughtsmen, 7 lithographers, 1 photographer, 5 printers, 4 printers' assistants, and in addition a number of comparing workmen.

The cost of the topographical and chartographical departments for 1875, exclusive of the salaries and allowances of the officers, was 470,000 marks, (about $117,500 gold.)

GEODETIC WORK.

The geodetic work is performed by the Geodetic Institute, which is under the direction of the ministry for spiritual, educational, and medical affairs. The Geodetic Institute executes the geodetic triangulations, makes the astronomical observations upon the vertices of the triangles, computes the co-ordinates of astronomically-determined points, makes comparisons of measures, and of levelings and water-mark observations for the determination of the relative levels of the European seas, and in addition performs the functions of the "Central Bureau of the European Degrees Measurements."

GEOLOGICAL WORK.

The geological surveys are executed by the Royal Geological Land Institute, which is under the direction of the ministry of commerce, industry, and public works.

TOPOGRAPHICAL AND GEOLOGICAL CHARTS.

Two sheets of the topographical chart and nine of the geological chart, all on the scale of 1:25000, have been sent to this office for examination.

For the purposes of publication and reference, each degree of latitude is divided into 10 equal parts, and each degree of longitude into 6 equal parts, so that each sheet represents an area of 10′ of longitude by 6′ of latitude. The rows of rectangles into which the country to be mapped is thus divided, are numbered between the even degrees from I to X from south to north, and from 1 to 6 from west to east, and position of each sheet is printed on its margin: *e. g.* $\frac{52^\circ}{51^\circ}$ of latitude, $\frac{29^\circ}{30^\circ}$ of longitude; range VI, sheet 4. The whole series of rectangles is numbered continuously also, and the number of each sheet in this series is printed also on its margin. The numbers of the adjoining sheets are printed on the margin at the four sides. An index diagram is printed on the outside cover of the charts. Two scales are drawn on each sheet, one of schritt and ruthen, (the schritt is equal to 2.47 feet, and the ruthen to 12.36 feet,) the other showing the slope of the surface in degrees corresponding to a given horizontal distance between the level curves.

The topographical sheets represent, by the usual conventional signs, the natural and artificial features of the country, with all the detail which the scale admits of without overloading. They show the rivers, streams, lakes, ponds, marshes, forests, woods, meadows, peat-bogs, mines, railroads, post and common roads, bridges, trigonometrical points with their altitudes, villages, detached houses, mills, toll-gates, brick-yards, lime-kilns, fences, and boundary-lines of provinces and districts. The relief is indicated by level curves at distances of 20 or 25 feet apart, according to the nature of the ground. The even hundred-feet curves are drawn full and heavy, and their altitudes are written upon them; the intermediate curves are drawn full and light, and their altitudes are not written. When necessary, extra intermediate curves are inserted, and these are drawn broken and light. Abrupt declivities, such as gorges, embankments, &c., are indicated by hachures. Where the country is broken, the exact altitudes of the summits of the hills are written upon them. The names of all the principal natural and artificial features of the country are given with sufficient detail.

The geological charts are made by properly coloring and referencing the above topographical charts. They appear to show very completely and

with much detail the geological features of the country. The different formations are indicated by various colors and combinations of colors, and these are further distinguished from each other by being lettered or numbered both on the body of the chart and on the index which appears on the margin. The localities at which borings were made or shafts sunk, the positions of mines in operation, and of those which are not worked points at which fossil animals or plants were discovered, the slope of the strata, the points where faults, slips, &c., occur are all indicated.

A descriptive text is published in connection with the chart.

Authorities.—Letter of Mr. Von Bulow, of December 2, 1875, and 11 maps.

Compiled by Lieut. P. M. PRICE, United States Engineers.

§ 3. MEMORIAL ON THE CREATION OF A GEOLOGICAL STATE INSTITUTE FOR THE PRUSSIAN STATE.

GENERAL UTILITY OF THE GEOLOGICAL EXAMINATION OF THE COUNTRY.

The geological survey of the country, *i. e.*, the exact examination of the inner composition and the constitution of the soil (earth) (*Boden*) of our country, is a problem in which not science only is interested.

Its results, deposited in geological maps and explanatory descriptions, are also of a direct value to the most important interests of practical life.

In mining, the geological knowledge of the rock-strata is the most important guide to the deposits of useful minerals, and the indispensable counselor for a successful working (*ausbeutung*) of the same.

Agriculture and forest management are not less interested in the geological examination of the country than mining.

An accurate knowledge of the composition of the cultivable ground and of the nature of its subsoil is the basis upon which they are carried on, (*ihres betriebes,*) and a new geological discovery or the finding of new mineral deposits may in the most effective manner influence the development of agriculture.

Reference may be had to Stassfurth, the inexhaustible source of salt for manure and for cattle, (*düngsalz and vieksalz,*) or to the discovery of the phosphorite-deposit in Nassau, or to the strata of lignite, with the discovery of which the development of the sugar-beet industry in many parts of the country is so closely connected.

It will be sufficient only to mention in how great a degree the results gained by the geological work, the pointing out of the building-mortar, cement-materials, &c., benefit building, (*bauwesén.*)

GEOLOGICAL EXAMINATIONS IN FOREIGN COUNTRIES.

The subject of the geological survey and mapping of the country, therefore, has in all civilized countries received the care and attention, not only of science, but also quite particularly of administrations.

England has possessed since the year 1835 an institute endowed with great means, the Geological Survey of the United Kingdom, which is devoted to this subject only.

Austria followed this example in the year 1849 by creating the K. K. Geological State Institute.

In the last years a geological state institute for Hungary was founded

in Pesth; in Italy the R. Comitato Geologico d' Italia; and in the kingdom of Saxony, also, ample means have been given by the government, (*landesvertretung,*) a short time ago, for the erection of such an institute.

In like manner British East India, the Australian colonies, and nearly all the States of the North American Union possess special institutes for the geological examination of the country.

In other countries, in France, the South German States, in Sweden, Norway, Russia, this work is not put in charge of a special institute; but it causes a continued activity and partly very considerable expenditures.

IMPORTANCE OF THE GEOLOGICAL EXAMINATION OF THE COUNTRY TO PRUSSIA.

Among all these countries there is not one to which the geological survey and mapping would be of greater importance than to Prussia.

Next to England, it is the farthest advanced in the opening and development of the natural sources of wealth which are concealed within the earth.

Prussian mining and the management of salt-works are developed on a large scale and are progressing rapidly; the value of raw production from that source amounted in the year 1870 to 70,500,000 thalers; in the year 1860 to 32,300,000 thalers. The value of the raw production of the smelting-works in 1870 was 142,500,000 thalers; in 1860 it was 63,550,000 thalers; while the total value of the mining-productions in the Austrian Empire, for instance, amounts to about 20,000,000 thalers, and that of the production of the smelting-works to about 22,000,000 thalers.

On the products of the mines and smelting-works a great industry of the most varied kind depends in Prussia, the productions of which contend for the first place in the market of the world, and which have in a large degree contributed to the foundation of the prosperity which our country enjoys.

Particularly, also, the relation mentioned between geological inquiry and the improvement of agriculture is of special importance in Prussia.

A very large part of the country is covered by a soil which, in consequence of its natural poverty, is very specially in need of the supply of enriching materials, among which may be mentioned lime, marl, gypsum, salts of potash, and phosphorite.

Even the pointing out merely of a solid stone stratum may be of great importance for the economic management (*Wirthschaftlichen Betrieb*) in many of our northern districts as a source of building and road-material.

PREVIOUS RESULTS OF THE GEOLOGICAL INQUIRY IN PRUSSIA.

The importance of the geological examination of the country for all the branches of economic activity has in Prussia been recognized a long time ago, and for a great part of the state a comparatively high degree of knowledge of the geological peculiarities (*verhältnisse*) has been reached just as early as, and even earlier than, in the neighboring countries.

The greater part of the mountain-country has been geognostically surveyed and the results represented on geological maps, which were very excellent for the time in which they were executed.

Of the provinces of Rhineland and Westphalia, a general geological map, in 32 sheets, on the scale of 1:80,000, has been prepared under the direction of V. Dechen.

Lower Silesia has been examined by G. Rose, E. Beyrich, Roth, and Runge, and drawn in 12 sheets, on the scale of 1 : 100,000.

The survey of Upper Silesia has only been completed a short time ago under the direction of F. Roemer, and represented, also, in a map of 12 sheets, on the scale of 1 : 100,000, which comprises part of the Russian-Polish boundary district.

Besides these general maps of extensive parts of the old monarchy, and some special representations of individual small parts of the same, belonging to the last decennium, we have, as geological representations of somewhat older dates, a map of Hanover, by H. Roemer, in 6 sheets, on the scale of 1 : 100,000, representing the southwestern part of that province; a special map of the surroundings of the city of Hanover, by Credner; a general map of the electorate of Hesse, by Schwarzenberg and Reusse; the geological map of the country of Schaumburg, and some other special maps of smaller groups.

Those parts of the mountain country which have not been newly represented in the geological maps referred to are contained in the older general maps of Fr. Hofmann, of Northwestern Germany, and of L. von Buch, of Germany.

Evidently, therefore, much has been done for the examination of the geological conditions of the greatest part of the mountain country of Prussia, and the results of these examinations have partly been made accessible for everybody by means of good maps.

FUTURE TASKS OF GEOLOGICAL INQUIRY IN PRUSSIA.

It would, however, be wrong to suppose that the work mentioned has sufficiently exhausted the subject for the time being. For, as it is shown by the above statements, new general maps are wanting for some of the most important parts of the country, *e. g.* for Nassau, Hesse, and a large part of Hanover. A very important task, although until now hardly commenced, then remains for the geological state-survey of Prussia—the examination and mapping of the northern plain.

Formerly the opinion obtained pretty generally that the geological examination of districts, the ground of which is formed by loose layers of the so-called diluvial and alluvial deposits, could not be of either scientific or technical interest, because of its too great uniformity, and because where a change is observed in the condition of the deposits, this is only accidental and not of a general character.

Latterly, however, it has become evident that these sands, clays, and marls of this so-called alluvium (*schwemmland*) also divide themselves, just like the layers of the older formations, into different subdivisions, which must be separated according to age and condition, and that the knowledge of the distribution of the different parts are valuable in a scientific as well as technical respect, especially for agriculture and forest management.

The survey and mapping of these territories in a proper manner, for which there are good examples existing in the geological map of the Netherlands by Staniег, and in the latest works by Dr. Behrend on East Prussia, would show itself to be very beneficial for their industrial development, and be at the same time of great scientific interest.

This would especially be the case if an examination of the older formations, forming the substrata of the diluvium, as also of the tertiary lignite-bearing formation, was, by means of numerous borings, united simultaneously with the examination of the surface.

In the case of such a methodically-managed examination of the northern part of the State the discovery of new strata of useful minerals could not fail, leaving aside the other benefits of the survey.

The individual important results of borings obtained in recent times at different points—Sperenberg, Inowraclan, Segeberg—open encouraging prospects in that respect.

With regard to the future problems of the geological state-survey, it must be remembered that even the best of the existing general maps can be recognized only as preparatory work in the direction of a higher end, which must be reached, the attainment of which has only just been entered on.

The enumerated geological maps, namely, as valuable and conscientiously prepared as they may be, are always only quite generalgeolo gical reviewing pictures, which indicate the limits of strata in general lines only.

They suffice, therefore, in many cases, for the exigencies of science, possibly also for the deduction of approximate conclusions as to the rock-stratification for mining purposes, for a general judgment as to the probability of the occurrence of useful deposits, their continuation, etc.

They are just as little sufficient to satisfy the exigencies of practical life, however, as the requirements of strict scientific accuracy and trustworthiness.

The scale of the existing maps is not nearly sufficient to make a complete geological picture possible.

If the limitation of the formations—and that not only of the main groups, but also of the individual subdivisions, of particular strata of special technical or agronomical importance, or certain occurrences, not very extensive but scientifically decisive—is to be represented on the maps strictly according to reality, it is technically impossible to do this in maps of the mentioned scales.

Considerably greater scales and far more detailed topographical foundations must be used than has been the case heretofore.

The fact that the geological representations could not, in the manner of execution heretofore employed, give such directly useful details, explains why the results of geological examinations have not become known by the public, which is largely interested in them; that, on the contrary, they and the geological maps remained for the main part the property of science.

To supply this want England has first started in the right direction. As the topographical basis for the geological general map of the United-Kingdom—consisting of 435 sheets—the map of the ordnance-survey has been taken, which is drawn on a scale of 1:63360, a scale exceeding that of our 1:100000 general map in surface $2\frac{1}{2}$ times, and therefore admitting of a more correct representation.

Of those districts, however, which show a particularly difficult stratification or such peculiarities that they contain the basis for a greater industrial activity, *e. g.*, the coal-districts, special geological maps are prepared on a scale six times as large as the stated one, viz, 1:10560.

Simultaneously, therefore, an already very clear general map is created, and the requirements of practical life are met with such representations as satisfy all its demands.

To follow the example of England is the problem for the future activity of the geological state-survey in Prussia, which possesses so many analogies with England in regard to the direct influence of the same on economic activity.

PRESENT PLAN OF OPERATIONS FOR PRUSSIA.

The performing of this task has been prosecuted with good results, according to the plan designed 5 years ago for the further geological surveys and mapping.

The principal map is a special map based on the plane-table sheets of the general staff in 1:25000, a scale which is in length 4 times, and in area 16 times, as large as that of 1:100000, heretofore used in preference to the general maps.

As the completion of the special map advances, the results will be newly placed together in general maps.

For the present this system is being carried out in the mountain regions, and the plan has been made so that the geological special map shall first be prepared for those parts of the country of which there exists new staff maps, viz, the province of Saxony, the Harz, the Electorate, the southern part of the Rhenish province, and Nassau.

In proportion to the completion by the staff of new plane-table sheets for other parts of the country, their geological examination will follow.

Agreements have been made with the Thüringian governments, according to which their dominions also are being now taken up in this survey in the same manner.

Of the special maps there are at present 52 sheets completed, partly in print and partly in manuscript.

The experience gained in this connection has shown that the scale upon which they are executed not only suffices to give a representation entering into the most accurate scientific details of the most complicated stratification even, but also that the picture given in the maps shows a limitation of the strata and kind of soil corresponding perfectly to reality, and thereby becomes a trustworthy guide for all purposes of practical life—for mining, quarrying, agriculture, and management of forests, public works, &c.

In this very beginning it has appeared that even in the outlines which the general maps give, corrections are requisite.

This can be understood from the fact that the conception and the representation of geological phenomena are generally subject to alterations in consequence of the advancement of science and of new discoveries.

In this respect the geological state survey is a continuous problem, the solution of which cannot in any time arrive at a final conclusion. Besides this the main reason for the difference between the total views (*gesammt bilder*) and the existing general maps (*uebersichts-karten*) lies in the different treatment itself.

The latter have for the greater part had their origin so that different districts have been surveyed independently of each other, and at different times, either through the initiative of individual observers or on the instigation of the mining authorities, whose interests are engaged in the first place.

Besides there mostly was a lack of sufficient assistance for the local observations, also of time, as in a short space of time extensive areas had to be represented, so that often dissimilar material had to be put together in the general maps.

In addition, they were not treated according to similar (uniform) scientific views, nor was the technical execution the same.

The proper road to avoid these drawbacks has again been first entered upon by England with the best success by placing all the operations for the geological survey of the country under the management of a special central office, the Geological Survey, founded in 1835, as stated above.

This was determined upon in consequence of the conviction that the adherence to a plan of operations for the surveys, beginning at the most prominent points, and then progressing systematically, and with a uniform conception and representation of what has been observed according to the actual state of science could not be effected in a different manner, and that the ways and means to introduce the scientific results in a beneficial manner into practical life also could, by proper combinations, be the most easily found from such a source.

It has been mentioned above that several other countries have followed the example of England.

Prussia cannot delay longer giving a solid organization to the geo logical state survey, if the problems still to be overcome are to be solved correctly and early, the great importance of which for the economic interests and its great extent have been shown in the preceding.

ORGANIZATION OF THE INSTITUTE.

The next question in organizing a geological state institute is to determine whether it is to be an independent institute, or whether it is to be united with a similar institution.

To arrive at a conclusion on this subject it is useful to have reference to those two institutions, which, existing a long time, have an acknowledged reputation, viz, those of England and Austria.

THE GEOLOGICAL SURVEY.

The "geological survey of the United Kingdom," in London, soon after its foundation was so organized that the highest establishment for instruction in mining, the Royal School of Mines, was united with it.

They received a common management and a common building. As, third, the Museum of Practical Geology, with a chemical laboratory, was added, a collection which consists mainly of two principal groups.

The first group is designated as that of the natural materials. It contains the collection for the geological maps, stones, petrifactions, &c.; the useful stones, building and mortar materials, marble, roofing-slate, &c., besides the other useful minerals, coal, ores, &c., occurring in the kingdom.

The second group, the artificial productions, contains a rich technological collection, illustrating in a very complete manner the use (*verarbeitung*) of the minerals of the first group in all branches of industry, especially in the metallurgical, ceramical, and chemical technics.

Other branches of the museum contain mechanical models of the mining and smelting-works technics and some historical material.

The collection is arranged in the most practical manner to satisfy every interest by which the public, in the most multifarious directions, is connected with it.

Finally, the Mining-Record Office—*i. e.*, the statistical bureau for mining—is also united with the institute.

Accordingly, the English institute has such an organization that it expresses the intimate connection between the science of geology and

mining, as also education in mining, the most important bases of which are the mineralogical sciences and the whole technological industry of the raw products.

By the admission of the Mining-Record Office into the institute the relationship between the development of mining and the geological pursuits is also pointed out.

DIE K. K. GEOLOGISCHE REICHS ANSTALT.

It differs from the "K. K. Geological State Institute." It is neither in any connection with the mining authorities, nor with a mining academy, nor with the university, nor with the mineral cabinet, but is completely isolated.

Temporarily the attempt has been made to take a number of the young men studying for the state mining-service annually to assist at the geological state institute. This combination was given up again very soon, however.

This institute is connected with a museum. The latter, however, is of an exclusively geognostic, paleontological, and mineralogical nature, and its contents are, in consequence, strictly scientific, but in this exclusive direction exceedingly rich.

ORGANIZATION FOR PRUSSIA.

If for the geological institute to be founded in Berlin one of these two foreign institutes should be chosen as model, it cannot be doubtful that the plan of organization carried through in the geological survey is by far preferable.

Evidently, the intimate connection between science and practical life which is attained there insures it the best success.

That this is so is felt in Austria also, and for some time efforts have been made to gain the natural connection of geological work and mining by instituting a mining academy in Vienna, in close union with the K. K. Geological State Institute.

CONNECTION WITH THE ACADEMY OF MINES IN BERLIN.

The elements of an organization, similar to the English one, for a geological state institute, to be erected in Prussia, are given more completely than was the case at the time of founding the Geological Survey in London.

The work of the geological state survey, which is being systematically carried out in the manner described above, belongs here to the department of the administration of mines.

The Academy of Mines already existing in Berlin is in a certain relation to the geological state survey in so far as the collections belonging to the latter are scantily accommodated in the building of the Academy of mines, as several of the geologists of the state survey are charged with lecturing at the academy, and as the director of the academy of mines is referee for the geological state survey in the mining department of the royal ministry of commerce.

A collection corresponding in part, and as a beginning to the museum of practical geology, is contained in the museum for mining and metallurgy, which is preliminarily accommodated on the premises of the royal iron-foundry.

The different parts require only to be completely united, being at the same time perfected and enlarged in order to form an organization answering its purpose in every respect.

ADVANTAGES OF THIS UNION.

The advantages of this union are evident.

Both institutions, the Academy of Mines and the Geological State Institute, have to a great extent similar wants.

The minerological and geological collections of the Mining Academy, of a more systematic scientific nature, are of great advantage as material for study and comparison to the state survey.

The topographical geological collections forming themselves during the state survey from the proof-specimens of verification (*als Belagsuiten*) will, on the other hand, serve as an excellent means of instruction for the mining academy.

The same obtains with the collection of maps and books.

The ministerial mining library in the mining academy, one of the most complete geological and technical professional libraries, is of great value to the state survey.

The laboratories of the Mining Academy can easily be made serviceable for the various examinations necessary for the geological state survey.

Next to the advantages of the use in common of the numerous objects qualified therefor stand those which are consequent upon the working together of the persons to be employed in the two institutions

In this respect, it is impossible to lay sufficient stress on the favorable influence exercised on the education of the students of the Mining Academy, whether they are preparing for the state service or for private industry, when the teachers of the mineralogical sciences, by participating in the labors of the state examination, are accurately acquainted wit the results and let them exercise a direct and fresh influence on their lectures.

It is therefore of the greatest value that the assistants of the state survey are also employed at the academy.

The order and superintendence of the mutual collections can be assigned to them.

On the other hand, this combination is very useful for the assistants themselves, not only in consequence of the contact with the mining interests which are represented in the academy of mines, but also on account of the impulse toward a more comprehensive scientific perfection given by the lectures which they have to deliver.

And then such a mutual activity of the fellow-workers and the mutual application of the required assistants, as draughtsmen, office-employés, and inspectors, will admit of a saving in expenses.

The utility of the union of the museum for mining and metallurgy and the geological state institute and the mining academy needs no further demonstration.

It is sufficient to point out its value as a means of instruction and as a completion of the total representation of the products of the soil of the country and of the industry depending thereon.

For the reasons represented in the preceding, it has been determined to found on the 1st of January next a Geological State Institute, in organic union with the Academy of Mines in Berlin, and thus to create an institute essentially similar to the geological survey.

Its objects have been explained previously. In regard to the execution, the following may be mentioned:

NECESSITY OF ERECTING A BUILDING FOR THE GEOLOGICAL STATE SURVEY AND THE ACADEMY OF MINES.

The importance of the subject for economic interests makes it necessary that the results obtained by the geological examinations be made accessible in the most general manner possible.

The specimens collected during the surveys for the geological maps, and the latter themselves, must therefore be publicly exhibited.

For such an exhibition and for the mere accommodation and examination of the material collected by numerous observers in the whole state considerable room is requisite, which in a proper form can be obtained only by means of a new building, for which an exigency exists, which is the more inevitable as the mining academy and the museum for mining and metallurgy cannot remain where they are at present.

The former, temporarily accommodated in the old exchange, is not able to permanently satisfy the requirements of instruction and means of education, since enlargements in the building cannot be made, and the building, even, will have to be torn down in consequence of the projects for the pleasure-garden and its surroundings.

The museum for mining and metallurgy will also have to be moved before long, as the premises of the royal iron-foundery will without a doubt find different application.

For the combined institute a new common building has therefore been planned.

HAUCHECORNE,
Oberbergrath.

Translated by F. W. Lehnartz.

§ 4. INTRODUCTORY REMARKS ON THE GEOLOGICAL SPECIAL MAP OF PRUSSIA AND THE THÜRINGIAN STATES.

The geological map of Prussia and the Thuringian states, of which the first 6 sheets have been published, is intended to be a special map in the real meaning of the word.

The topographical basis for the same is the fundamental map-work of the Prussian staff, the so-called plane-table sheets, whose scale of $\frac{1}{25000}$ is so large that all the information gained can be completely and accurately located, and the geognostical boundaries represented with an accuracy that will make them correspond exactly to reality.

The method of equidistant horizontal curves, applied to represent the relief at a vertical distance of 25 feet, drawn so that every 100-foot curve was a little heavier, in order to facilitate a more ready review, makes it possible to accurately locate and read off the real heights of all points, and, in comparison with the representation of the relief by means of hatching, it offers the advantage of greater distinctness of the whole topography as well as of the geological limitation.

For the geological work the whole topography of the original surveys of the staff is retained, so that the maps in this form are the most accurate special maps existing in point of topography.

The extent of this map-work will be very considerable. It will, first of all, cover the mountainous part of Prussia and of the Thuringian states, the governments of which have acceded in the most accommodating manner to the working-plan, so that it will extend in the south to the boundaries of Prussia and of the North-German Confederation as far as they are formed by the boundaries of the Thuringian states.

Within that extent those districts will be geologically surveyed first,

for which new maps of the staff, representing the ground by means of equidistant horizontal curves, exist.

This is at present the case with the province of Saxony and with the East Harz, with the formerly electoral part of Hesse, with the southern part of the Rhenish province, and with the Thuringian states.

Of the former dukedom of Nassau the plane-table sheets are at present being prepared.

After their completion the southern part of the province of Hanover will be surveyed in a similar manner.

In the measure in which similar topographical maps are completed by the staff for other parts of the state, the geological survey will gradually be extended.

At present geological surveys are being executed in the province of Saxony, in the Harz, in the Thuringian states, in Hesse, and in the Rhine province.

Assuming as a limit for the time being for the Saxon-Thuringian group toward the north the parallel of the north border of the Harz at Vienenburg, toward the east more or less the thirtieth degree of longitude, which is not quite reached near Halle and at the Saxon frontier, but crossed by the territory of Saxony, Altenburg approximately just as much, then the Saxon-Thuringian group consists of 268 plane-table sections, each of which contains an area of $2\frac{1}{4}$ square miles.

The former electoral Hessian territory contains 112 sections, Nassau will contain 55 sections, the southern part of the Rhine province about 110 sections, the former Hanoverian territory between the Harz and Hesse about 30 sections, so that there are here all in all 575 sections in immediate connection with each other to be surveyed.

The organization of the geological surveys is at present arranged in the following manner:

Within the territory, which is to be first begun, the surveys are executed in groups, which connect partly with the special preparatory work done formerly and partly correspond to the places of residence of the assisting geologists, so that the separate groups will gradually close, to become a whole. Such working districts are at present as follows:

1. The Harz is being surveyed by Prof. Dr. Beyrich and Dr. Lossen. The 6 sheets published with this number, which contain the Lower Permian conglomerate and sandstone, together with the Plutonic formation (*Eruptiv gesteine*) of the district of Ihlefeld and the sublying older Hercynian strata, and a part of the belt of magnesian limestone (*Zechstein*) inclosing the Harz, belong to this group.

The sheets in question will be followed, from this part of the work, by the sheets connecting with the former in the east and extending over the older Hercynian formation of the East Harz.

2. The Thuringian Triassic basin, (*Triasbecken*,) closing with the Harz in the south, is being surveyed by Dr. Eck, Prof. V. Seebach, and Berg assessor Giebelhausen, beginning with the Ohm Mountain and its surroundings, between Nordhausen and Göttingen.

Farther east the nearly-finished special survey of the Kyffhäuser by Prof. Dr. Beyrich, will join.

3. The porphyry and the Lower Permian formation (*Rothliegende*) conglomerate, and the Carboniferous, as also the diluvial formation of the district of Halle, have been examined by Dr. Laspeyres.

The surveys are being continued by Assessor Giebelhausen, as Dr. Laspeyres has been called to the polytechnic school at Aachen.

4. The south Thuringian Triassic of the district of Jena, Weimar, and

Erfurt is being examined anew by Prof. Dr. Schmid, of Jena, who will also survey a part of the inner Thuringian forest.

5. The Lower Permian formation and a part of the Plutonic formation (*Eruptiv gesteine*) of the West Thuringian forest are being surveyed by Prof. Dr. Roth.

6. Joining these sections in the west Dr. Mösta, together with Prof. Dr. Beyrich, surveys the Permian limestone (*Zechstein*) and Triassic formations of the Werra valley, beginning in the neighborhood of Eschwege and Sontra.

7. The surveys of the Zechstein formations of the southern border of the Thuringian forest and of the Trias of the upper Werra valley are being executed by Prof. Dr. Emmrich, of Meiningen, beginning in the sections Meiningen, Salzungen, Dorndorf, and the surrounding sections.

8. Beginning at Saalfeld, Director Dr. Richter is preparing a map of the slate-formation (*Schiefergebirge*) of Thuringia and of the adjoining more recent formations.

9. The section of Prof. Dr. Liebe in Gera will join to the former in the east.

10. Dr. Weiss, finally, is executing under the special direction of Dr. V. Dechen, the survey of the Carboniferous formation of Saarbrücken.

As soon as the plane-table sheets of Nassau are printed, the preparation of the geological special map will be begun.

In order to insure uniformity in the scientific conception and the graphical representation, so many assistants taking part in the extensive work, one of the co-laborers, Prof. Dr. Beyrich, of Berlin, has been charged with the scientific direction of the geological survey and mapping of the Prussian states, and, by the agreements made with the Thuringian states, a uniform (similar) treatment of the contributions furnished by them for the mutual undertaking has been secured.

All the finished maps, or those ready to be published, of the different assistants, are delivered by the same to the directo y of the geological state survey in Berlin, which consists of Prof. Dr. Beyrich and the referree for these matters in the department of mines of the royal ministry of commerce, trade, and directory of the public works, at present Bergrath Hauchecorne, director of the Academy of Mines.

This central bureau effects the final editing, and after the edited sheets have been sent to their authors for a last revision and obtained their assent to the final review, the publication is printed. Of course, every one of the numbers when it appears bears the name of the respective observer.

At a meeting of the assistants, which takes place every year at the general conference of the German Geological Society, the work which has been done is presented and discussed.

The offices of the directory of the geological state survey are in the Academy of Mines in Berlin.

As vouchers for the geological maps a comprehensive collection of the stones, petrifactions, and minerals gathered during the surveys is formed here, which will become, as it enlarges, a geological state museum, for which an organization as a public institute has been planned.

Heretofore this collection has been restricted to Prussian territory.

Besides, there have been fitted up at the Academy of Mines, for the purposes of the geological state survey, a draughtsman's office and a chemical office in the academical laboratory, standing under the direction of Prof. Dr. Finkener, for the examination of the collected stones, minerals, and useful fossils.

The finished maps will be published in numbers, which, like the present one, consist of several contiguous sheets, and will contain, as far as possible, a complete geognostical district.

After the present number there will very soon follow 12 sheets on the district of Jena, by Prof. Dr. Schmid; 6 sheets on the Ohm Mountain and the district of Bleicherode, by Dr. Eck, Prof. von Seebach, and Assessor Giebelhausen; 3 sheets on the district of Halle, by Dr. Laspeyres; and 6 sheets on the formerly electoral Hessian Triassic and Permian region of the district of Eschwege, by Dr. Mösta and Prof. Dr. Beyrich.

There are also nearly completed 6 sheets containing the Kyffhäuser Mountain, 4 sheets on the East Harz, uniting with the sheets now published the sections Saalfeld and Meiningen, and the first 6 sheets of the southern part of the Carboniferous formation of Saarbrücken.

For several other sections work has been executed which is far less advanced.

With this state of the preparatory work, the publication can take place in quick succession.

The sale of the maps, which has been intrusted to Neumann's map-establishment, will take place so that every section will be sold singly for the low price of 20 silbergroschen, so that, in accord with the character of the work, a special map, not only the scientific interest of the professional student but also particularly the local interests of the farmer, the forester, the miner, and of technics generally, may be satisfied as much as possible.

For the solution of this problem, it appeared advisable to add an independent short text to every sheet, which gives the explanations necessary for the general understanding of the established geognostical conventional signs.

This explanatory text will, in this connection, not discuss any scientific controversy, nor give literary references, but will confine itself to pointing out in as comprehensive a manner as possible the local peculiarities of every sheet.

In this manner numerous repetitions in the explanations for contiguous sheets cannot be avoided, even though in the more explicit remarks in regard to separate geognostical circumstances in the text for one section that of a neighboring section will be frequently referred to, in which the respective occurrences appear to be especially developed.

Besides these short explanations, full descriptions will be published of larger adjoining districts, and dissertations on specially important observations will be published in the form of essays, as far as there may be material for such.

In regard to the position of the separate sections in each number, a sketch of part of the total map-territory on the binding of the number will give the necessary information, showing the plane-table sections, according to the general net of the staff, with the number of each section and of the group to which it belongs, and where the sections concerned are made prominent by hatching.

May the great and difficult work begun herewith furnish a great many new discoveries (*Bausteine*) to geological science.

May it at the same time approach its second object as much as possible, to gain numerous new friends for the examination of the soil of our country and to make this knowledge the common property of all.

BEYRICH HAUCHECORNE.

Berlin, July, 1870.

Translated by F. W. Lehnartz.

§ 5. Instructions for the Royal State Geologists.

1. The royal state geologists have to perform their services according to the instructions and under the supervision of the directory of the Geological State Institute.

2. *Sphere of business.*—The services of the royal state geologists consist of—

(1) The local surveys for the geological maps which are published by the Geological State Institute.

(2) The preparation of the geological maps for the examined districts.

(3) The preparation of the explanatory text for these maps.

(4) The scientific work on the petrographical, palæontological, and mineralogical material collected during the surveys.

Besides, the state geologists have to obey any special orders from the royal ministry of commerce or the directory of the Geological State Institute in regard to the state survey and the respective collections.

3. The state geologists living in Berlin have to assist as lecturers on the mineralogical sciences at the Academy of Mines, and to perform the work on the parts of the collections of the Geological State Institute which may be assigned to them. They will receive definite instructions, in regard to the lectures and the work in the collections, from the directory.

4. *Surveys.*—The territory to be surveyed each year by the state geologists is determined by the directory, according to the plan of the work and the state of execution at the time being.

As a rule, the whole summer-semestre, or at least five months of the same, is to be employed for the survey.

A different use of a part of this time, for such scientific purposes as do not come within the scope of the work of the Geological State Institute, can be made only after special approval of the directory.

5. *Mapping.*—The results of the survey have to be drawn into the respective sheets of the map, and must be made into geological representations completely colored, so that when the whole extent of a map-section is completed it can be turned in ready for publication. Even if the whole extent of the section is not surveyed, but only one part of the same, that part must be nevertheless filled in with formation-limits and geological coloring.

Particular (*Aufschlusspunkt*) maps are to be drawn only of those districts which the directory has specially indicated.

6. *Explanations.*—For the geologically-surveyed sections explanations must be written.

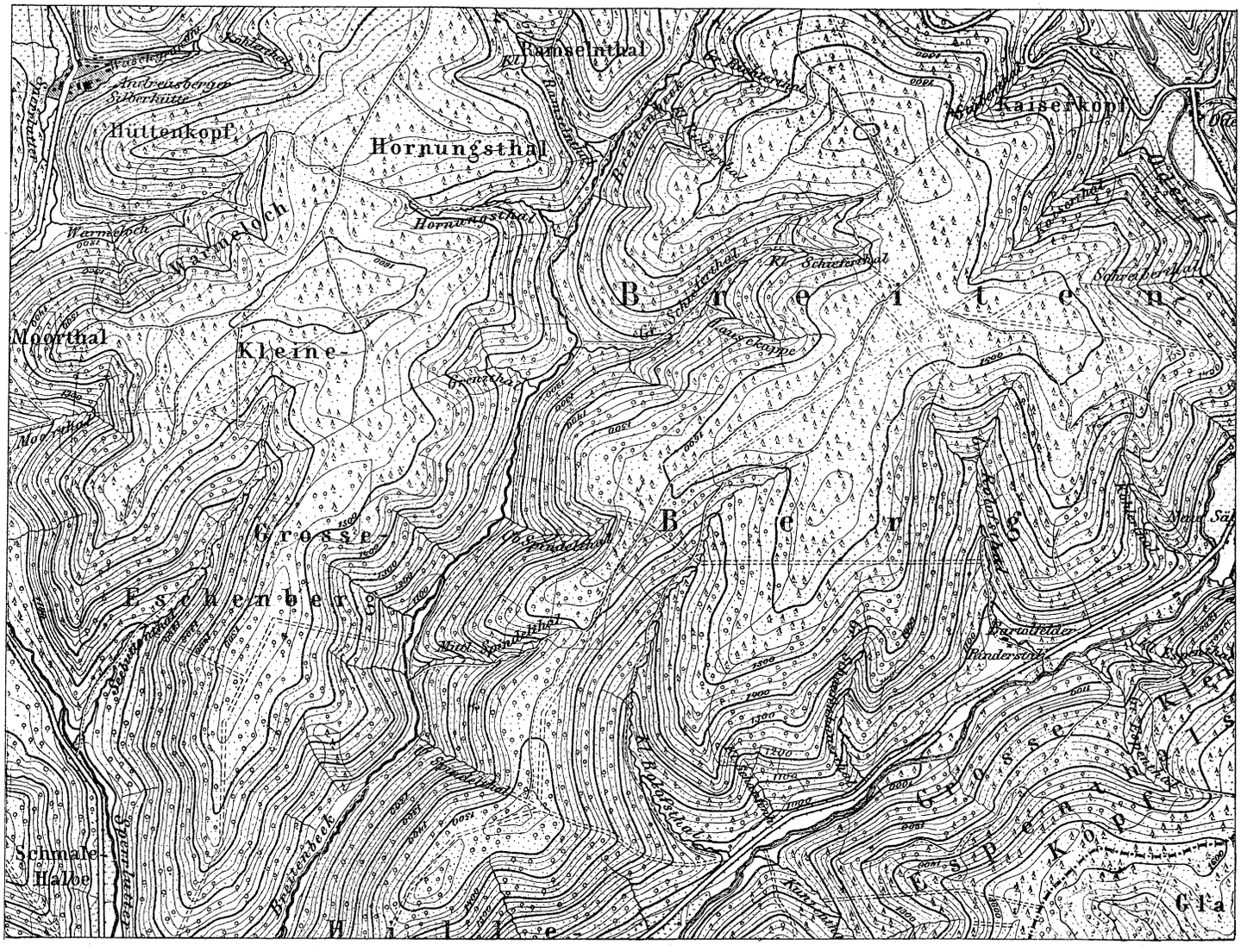
For the completed sheets they must be brought into such a form that they can be published as text for the same.

For the sheets that are only partially worked out explanatory reports must be prepared in a similar manner.

Besides the material for the text, notes must be taken, during the survey of everything that may be of interest, for the geological archive, *e. g.*, boring-records, existing geological preparatory work, profiles, &c.

7. The executed maps and explanatory reports, as well as the other mentioned notes, must be delivered to the directory in the course of the month of December of the working year, and certainly previous to the 1st of January of the following year, in a complete form, according to the above directions, sub. 4 and 5, together with a short letter of transmittal and a liquidation of the traveling-expenses.

The maps, whether they be entirely or only partly completed, must be handed in clean, drawn on uncut sheets, the explanations in clean



Surveyed by the Royal Prussian Gen. Staff in 1858

Scale 1:25000

Contours 2½ Ruthen or 25 Dec. Feet apart

½° 1° 2° 3° 4° 5° 10 15 20 30 45°

Note

A Ruthe = 12.35667 Eng. Ft. Decimal Foot = 1/10 Ruthe = 1.235667 Eng. Feet

copy. They are not returned to the authors, but are destined for the archives.

8. *Verifying collections.*—Verifying collections of a petrographical, palæontological, and mineralogical nature are to be made for the districts under survey, destined for the geological state museum.

In this connection, however, only such occurrences are to be noticed as are of a special scientific or collection interest and have a characteristic proof-importance for the respective locality.

A size of about $7\frac{1}{2}$ to $10\frac{1}{4}$ centimeters is to be given to the mineralogical specimens.

If within the section under survey, local collections having reference to the same are found, the acquisition of which for the geological State museum appears to be desirable, they may be bought for it by the state geologists without further notice, if the price does not exceed 25 thalers. Should the price be higher, the sanction of the directory will be necessary.

To develop particular deposits, laborers' wages may be paid, also, however, not to exceed 25 thalers in one surveying period, without special sanction of the directory.

Original receipts must be taken for purchases, as well as all other expenditures for labor, packing, transportation, &c., and presented for settlement at the same time as the traveling-expense liquidation.

9. The principle must be adhered to that all the scientific material collected during the survey is the property of the geological state museum. Upon special instruction of the directory, duplicates for scientific provincial institutes, universities, &c., may be picked out and transmitted by the directory.

10. *Preparation and delivery of the collections.*—The objects collected during the surveys must be arranged during the winter succeeding the time of the survey, and provided with labels according to the rules of the state museum, and delivered to the directory for admittance into the museum.

11. *Liquidation of traveling-expenses.*—The liquidation accompanying the report on the work done and to be handed in in the course of December must show the number of days employed on the surveys and the cash-expenditures, the latter, as mentioned above, with original vouchers.

After the liquidation an advance may be given out of the (*oberberghauptmannschaftlichen*) contingent fund upon special application. The application must be made to the directory.

The above instructions are herewith approved.

Berlin, August 13, 1873.

The Minister of Commerce, Trade, and Public Works,

Dr. ACHENBACH.

Translated by F. W. Lehnartz.

CHAPTER IV.

§ 1. Memoir on Austrian surveys.

The K. K. (Austrian) Military Geographical Institute is charged with the survey of the whole empire, and of the production and publication of the maps based on the same, and also of the production and multiplication of the maps, plans, and drawings necessary for the use of the army, with a view to as great general usefulness as possible, and with the application of the method of representation which is the best suited for the purpose at the present time; it also has to furnish geographical and topographical aid for other branches of the administration and for private enterprises, as far as can be done with the force and means of the institute to meet such special requirements without injury to its proper object. In war-times the institute has to provide the commanders and staffs of the armies and army-corps with maps. Accordingly its work naturally consists of three parts: the trigonometrical triangulation, together with the respective astronomic-geodetical operations, the production of the field-sheets, and the drawing of maps, which have to take place in this order in the work of the institute.

It is an army-institute, under the war-department, through the chief of staff, and is directed by a general. All the members of the same consist partly of officers, military officials, and the technical assisting force, non-commissioned officers; then, for the lower services, of soldiers, and also, as occasion may demand, of workmen engaged by agreement. It is a rule that officers are employed for the scientific and field work, (triangulation and map-production;) for the purely technical work, however, officials, although this rule is subject to modifications.

The officers and officials of the institute draw a fixed salary, advance in rank and salary according to their categories, when vacancies occur, and, in case of their being disabled for service, they are entitled to a pension. The vacancies occurring in the lowest grades of the technical officials in consequence of such promotions are filled from the ranks of the army or from the contract-workmen, for whose engagement from civil life the directory of the institute is authorized, according to requirement and disposable funds, for a compensation fixed by agreement The candidates for such places must be healthy, and must have passed for this purpose a technical examination with good result, after which their appointments, upon the recommendation of the directory of the institute, are made by the war department.

The institute consists at present of the following departments:

1. Adjutant's department.
2. Military triangulation.
3. Military-map production.
4. I. Group consisting of—
   - *a*, topographical department.
   - *b*, lithography.
   - *c*, copper-engraving.
   - *d*, topographical school.
5. II. Group consisting of—
   - *a*, presses, book-binding.
   - *b*, galvanoplastics.
   - *c*, photography, photolithography, and heliogravure.

6. Map correction and revision.
7. Archives and library.
8. Consumption of maps.
9. Commission of administration and account-office.
10. Non-commissioned officers' department.

1. ADJUTANT'S DEPARTMENT.

This consists of one captain as chief, who is aided by a second officer for assistance in his work and by six non-commissioned officers to do the current writing and forward the manuscripts and maps.

It receives all the manuscripts sent from outside or from the departments to the directory of the institute, where they are recorded and referred to the respective departmental chiefs, or to the directory of the institute. Besides, the adjutant's department keeps a record of all personal matters, and of all papers bearing on the relations of position and service, and disposes of the same in the proper manner.

The number of official documents annually amounts at present to about 34,000. The number of those official documents sent out annually from the directory to the different departments of the institute amounts to about 13,000; 4,000 official letters and about 2,000 packages or rolls with maps for the city; 10,000 official letters and 13,000 packages or rolls with maps, and 1,000 money-packages, with about 400,000 fl. ö. w., sent out of the city, (*nach auswärts.*)

2. MILITARY TRIANGULATION.

This department consists of 1 higher staff officer as director, 1 staff officer as representative, 8 captains, 14 first lieutenants, 6 lieutenants, and 3 non-commissioned officers as observers and computers.

For the field-work these individuals are formed into parties of 2 to 3 officers, (1 trigonometer and 1 to 2 assistants; for base-measuring generally, 4 to 5 officers,) and each party is assigned to a special field of work.

The military triangulation is charged with the execution of the trigonometrical field-work and computation as bases for the succeeding graphical military state survey and for the cadaster,* as also in part for the scientific purposes of the European *Gradmessung*, which is now in progress. The latter falls within the extent of the monarchy in its astronomical part in charge of the commission of surveyors and astronomers, appointed by the K. K. administration, and to which the director of the triangulation also belongs, under whose special direction the geodetical work of the *Gradmessung* is executed, that falls to the care of the institute. Two officers of the triangulation-division have been assigned to that *Gradmessung's* commission as assistants and computers.

The other work of the triangulation-division consists of the execution and computation of a net of triangles of the first and second order, covering the whole monarchy, together with the necessary measuring of bases, determinations of latitudes and azimuths at points selected for that purpose in this net of triangles, and in the formation and computation of an interpolated net of triangles of the third order for the use

* This is a department of the finance-ministry which conducts the cadastral triangulation, and the state survey of the cadaster, based thereon, on the scale of $\frac{1}{2880}$, for the purpose of determining the ground-tax, not paying attention to irregularities of the ground.

of the state survey, the angle-points being determined in a horizontal as well as in a vertical sense.* It consists furthermore of the computation of the geographical positions and polar co-ordinates of the angle-points; the precision-levels, executed with specially-constructed leveling-instruments for the European *Gradmessung*, astronomical determinations of positions, and measurements of heights by means of aneroids in neighboring countries which have not yet been surveyed, together with descriptions of routes and of military reconnaissances; the computation and construction of the new sheets for the degree-map,† and the special maps of Austria-Hungary; the computation of the rectangular co-ordinates of all the corner-points of the military sections necessary for the production of the field-sheets, so that the outlines of the survey sections can be given according to degrees and constructed; the compilation and publication of the astronomic-geodetical work, executed for the purposes of the European *Gradmessung*, as well as the levels and the remaining triangulations. To execute these works the triangulation directory has at its disposal the following instruments:

One fixed transit telescope, with straight telescope of $1^{m}.32$ focal distance and 79^{mm} aperture of object-glass;

One large universal-instrument, with broken telescope, with 53^{mm} objective aperture, and 60 and 90 fold magnifying power; horizontal, as well as vertical, limb has 34^{cm} diameter, and two microscopes, permitting the reading of 1 second and the estimation of fractions of the same;

One large universal-instrument, with broken telescope of 46^{mm} objective aperture, magnifying 60 and 90 times; the azimuth-limb has $31^{cm}.6$, the vertical limb 26^{cm} 3 diameter; each has two microscopes, admitting of directly reading off 1 second and estimating fractions of the same;

One large universal-instrument, with telescope in the axis, objective aperture 46^{mm}, magnifying 40 and 60 times. The 2 limbs have diameters of $26^{cm}.3$, and have each 2 microscopes, with direct reading of 1 second;

One small universal-instrument, with broken telescope; limbs of $13^{cm}.2$ diameter, with 2 verniers, giving a direct reading of 10 seconds;

One small universal-instrument, with broken telescope. Both circles have diameters of $10^{cm}.5$, with 2 verniers reading to 20 seconds;

One small universal-instrument, with telescope in the axis. The 2 circles have diameters of $7^{cm}.9$ and 2 microscopes, giving a direct reading of 5 seconds;

Two large portable transit-instruments, with broken telescopes of 66^{mm} objective opening, magnifying 60, 90, and 120 times; one has a striding, the other a hanging level;

One small portable transit-instrument, with broken telescope 46^{mm} objective opening, and striding level;

Five theodolites of new construction; telescope can be reversed; horizontal circle has 26^{cm}, vertical-circle 21^{cm} diameter; both movable, and each with 2 microscopes giving a direct reading of 1 second;

Two theodolites of equal construction as the previous ones; horizontal circle with diameter of 21^{cm}, and vertical circle with diameter of 20^{cm};

One repeating theodolite of old construction, horizontal circle 31^{cm},

* For the extent of the former, now abolished, military boundary, (*Militärgrenze*,) the triangulation and computation bureau of the institute had also to fix a net of triangles of the third and fourth order for the works of the cadaster.

† Every whole sheet of the degree-map comprises 15 minutes geographical latitude and 30 minutes geographical longitude, by the meridians and parallels of which it is bounded in the form of a trapezoid, and contains 4 military survey-sections. It is drawn on the scale of $\frac{1}{75000}$, and is provided at the ends of the borders with numbers which indicate the longitudes and latitudes of the border-lines.

with 2 microscopes and direct reading to 1 second; the fixed vertical-circle has 22^{cm}, with 2 verniers, giving a direct reading of 10 seconds;

Two repeating theodolites of similar construction as the previous one, but the horizontal limb has 26^{cm}.3, and the vertical-limb 20^{cm} diameter.

With the exception of the fixed transit-telescope, all the previously-mentioned instruments are from the mechanical establishment of G. Starke, at Vienna.

One repeating theodolite, of Ertel, in Munich, horizontal circle 2[illegible]^{cm}, vertical circle 19^{cm} diameter, each with 2 microscopes and direct reading to 1 second;

One repeating circle, by Borda, of about 40^{cm} diameter, not used since the year 1859; and

One old non-repeating theodolite, by Reichenbach, with horizontal circle of 21^{cm} diameter, and vernier reading, not used for a long time;

Two Gauss's heliotropes;

Four Starke's heliotropes;

Thirteen Bessel-Baeyer heliotropes;

Two Steinheil's heliotropes;

One base-measuring apparatus, after Delambre, contains 4 iron rods, each 2 toises long, 1 plumbing arrangement, and a leveling-instrument, &c.;

Eight leveling-instruments for precise levels, by G. Starke;

One astronomical clock, by Molyneux, with mercury compensation;

One astronomical clock, with gridiron compensation;

Eight traveling chronometers;

One standard mercurial barometer, after Fortin and Gay-Lussac, by Kapeller;

Aneroids and thermometers in great number, likewise scales, measuring-tapes, &c.;

One magnetic theodolite;

One inclinatorium;

Two pyrheliometers;

A special observatory in the building of the institute for practicing in the use of the instruments and in observing.

3. MILITARY-TOPOGRAPHICAL DEPARTMENT, (MAP-PRODUCING DEPARTMENT.)

It consists of 1 higher staff-officer as director; then of 16 topographic divisions, each of which consists of 1 staff-officer or captain as subdirector, 8 officers as topographers, and 1 non-commissioned officer as clerk. Every subdirector, or topographer, has assigned to him for the time of the field-work 2 soldiers, (in case of need 3 or 4,) as laborers.

The military-topographical direction supervises also the military drawing and pantograph divisions, the first of which consists of 20 to 24 officers, and the latter of 10 officers and 20 non-commissioned officers, and both are superintended by a staff-officer as representative of the topographical director.

The object of the military-drawing division is, in the first place, to further educate officers of the army who have a sufficient elementary knowledge in drawing and mathematics in those branches of science which are necessary for carrying on the military survey. Those branches are, lower geodesy, topographical drawing, knowledge of the earth's surface, tactics, besides exercise in the use of surveying-instruments and in the necessary height-computations. Here also corrections

are made in the original sheets, for example, in the case of streets, railroads, &c., according to newly-obtained data, newly-measured heights and lines of equal altitude are drawn in, and modeling work according to relief-drawings is prepared. To assist in their better education the pupils hear daily lectures delivered by the staff-officer representing the topographical director, and at the close of the year they must assist in a six weeks' survey for practice.

The object of the pantography is, to prepare graphically, on the scale of the survey, the section-borders, or the borders of the survey-sheets, according to the computed degree-map sheets; to reduce into the same the cadastral maps drawn, without relief, on the tenfold scale of the military-survey sections, to the scale of the survey: to draw, in a preparatory manner only, the roads, towns, cultivations, &c.; partly to color them after the trigonometrical points have been carefully plotted by means of rectangular co-ordinates; then to prepare the parish boundaries and descriptions.

The work of the military-topographical department consists of the graphical survey of the country, and the military description of the same, namely, in regard to the first, in regions where there are no cadastral surveys in existence as yet, it consists of a completely new survey, and where cadastral surveys have already been made, in a survey on the basis of the pantographically-reduced cadastre-maps; in both cases determining numerous elevations by means of special height-determining instruments.

All the state surveys are plotted on the scale of 1:25,000, except in particular cases—for instance, large cities and their surroundings, manoeuvring and camping grounds, &c., which are drawn on the double scale, $\frac{1}{12500}$ within such borders as the arrangement of the map, according to degrees on the one hand, and the size of the sheet on the other, demand, in quarter-degree map-sheets. Where cadrastral surveys do not exist, and where, in consequence, such cannot be used as bases for the state survey, the topographical department receives the distances of certain fixed points, determined by means of astronomo-trigonometrical operations, and computed by the triangulation-division, together with their elevations, to such an extent that every quarter-degree map-sheet usually contains three, or in the worst case at least two, such fixed points, with one or two (even if beyond the border of the sheet, yet close to the same) third or third and fourth ones, all being well situated and intervisible. Such a quarter-degree map-sheet, denoted as northwest, northeast, southwest, southeast section of the respective degree-map sheet, is fastened on the plane-table, and the survey completely executed on the same on the basis of the trigonometrically-determined points, which have been plotted on the sheet, beginning with a triangulation with stations determined by the topographer himself, (*nach selbst-gewä'hlten Punkten.*)

When the cadastre-surveys, executed on the larger scale, can be used as bases for the military state survey, then the degree-map sheets are planned according to the survey-scale, the skeleton contained in the cadastre-sheets is, by means of the pantograph, carefully reduced and drawn into the same, making use of the carefully-plotted trigonometrical points, and these reductions, drawn in pencil, distributed among the topographers in section-quarters. Accordingly the graphical triangulation of the topographer becomes unnecessary, in so far as it will be required exceptionally only, for the determinations in the horizontal net, when extensive corrections are shown to be necessary. Special points, the absolute heights of which it has been found necessary to determine,

are, however, in this case, also established by triangulation. The to, pographer has, therefore, in reality, only to make a revision (*Reambulirung*) of the skeleton, changed since the cadastre survey, and to plo the ground-irregularities at sight, together with the height-determinat tions; during the winter-months, however, the complete draughting of the summer's survey has to be executed.

The basis for the height-determinations is given by the results computed by the triangulation-department. Based on the trigonometrically-determined points of elevation, the topographical subdirector, within the limits of his division, determines with his universal instrument, for every topographer, such a number of well-controlled points that he may be enabled to interpolate any number of new points of height. With the universal instrument zenith-distances are measured, from which the differences of height are computed. The horizontal distances needed for this purpose are either computed from the triangle observed with the universal instrument, or are carefully taken from the sheet with the dividers. Every topographer is provided with a small instrument for measuring heights, with which he can, like the subdirector, determine and compute the required differences of elevation. Besides this, the topographer has good aneroid barometers by Naudet at his disposal, for measuring heights in woody regions. In this manner, there are, on an average, at least eight well-distributed heights determined per square kilometer, which the topographer makes use of, in order, during the winter, to plot lines of equal elevation, 100 meters apart vertically in one manner, and 20 meters apart vertically in another manner, in red brown color, on the basis of these measured heights and of the lines of greatest inclination that had been judged of by sight and sketched on the ground. The execution of this work is the summer occupation of the topographer, which period extends from May 1 to the end of October.

Each topographical division remains during the winter in one of the principal towns of its district, or of the district assigned to it for the following year, where, in November, it begins the winter-work, which consists of the construction of the contour-lines and the complete clean-drawing in color, according to the adopted conventional signs (*nach dem bestehenden Situations-Zeichnungsschlüssel*) of the country surveyed during the summer; the hachure of the irregularities is done in black, according to the established shade-scale in the manner of Lehmann.

An experienced topographer can survey during the summer months, according to his aptitude and to the nature of the ground, on an average, from 350 to 500 square kilometers, with about eight height-determinations per square kilometer; on the double scale about 150 to 230 square kilometers, with about 17 heights per square kilometer; compute the measured heights, and plot the same in winter.

It is the duty of the topographical director to conduct and superintend the uniform execution of the survey, strictly in accordance with the existing instructions, subject to the deciding influence of the directory of the institute, for which purpose he inspects all the divisions during the summer, and carefully examines the elaborate maps of the topographers, already revised by the subdirectors and forwarded to the directory of the institute at the close of the winter, and reports upon the same to the directory of the institute. He is, moreover, charged with the appropriate distribution of the districts to be surveyed, to the subdirectors, the direction of the officers' drawing-school, and the pantography.

I GROUP.

This is charged with the reduction of the military surveys to the scale of the maps, the preparation of the drawings required for the heliography, as well as all other map-drawings, and the direct (*unmittelbare*) engraving of maps on stone and on copper, and finally the correction of the heliographically prepared plates. This consists of 1 higher staff-officer as chief of group, 1 staff-officer as chief of the topographical division, 2 officials with analogous rank, as chiefs of the divisions of lithography and of copper-engraving, and one captain as chief of the topographical school, together with the requisite assistance.

a. Topographical division.—Sixty individuals, partly officers, partly officials, partly non-commissioned officers, are employed in the same. Its office is, to furnish drawings so that they, according to their purpose, may serve either as hand-drawings or for the different manners of reproduction, as heliography, lithography, copper-print, photography, photolithography, &c.

b. Lithography.—Here the stone-plates are completely prepared for the print, on the basis of direct or photolithographically prepared tracings, (*pausen,*) in the various kinds of lithography, either engraved, or in autographic ink, or in chalk, &c. This division is conducted by a technical superior official, under whom are lower officials and non-commissioned officers.

c. Copper-engraving.—In this division, which is also conducted by a technical superior official, 24 officials and non-commissioned officers are employed. They have to make the corrections in the copper-plates prepared heliographically, engrave the graduation (*gradirung*) and the scales, and make the required corrections in the lettering and in the skeleton. Besides that, they have to make the additions and corrections in the copper-plates prescribed by the revision and the correction.

d. Topographical school.—In this there are at present occupied 75 officers or non-commissioned officers under direction of a captain, part of whom are now occupied in the drawing of the skeleton, and the other part with the representation of the irregularities of the ground for the new special map of Austria-Hungary. Its object is to develop draughtsmen competent to furnish drawings which are perfectly fitted for heliogravure, and who will in future independently execute such drawings themselves. Drawings from which a good heliogravure shall be obtained must be drawn with quite black ink and sharp edges. The paper must not have suffered any noticeable damage in consequence of erasures. Draughtsmen who work for the heliogravures must, therefore, be particularly well schooled.

Of the state survey on the scale of 1:25,000, where four survey-sections form one degree map-sheet, a copy on the scale of 1 : 60,000 is prepared for the topographical draughtsmen, who use the same to draw the special map-sheet on the same scale, and thoroughly in black. This original drawing, executed on a whole undivided sheet, is photographically reduced to the special-map scale of 1 : 75,000, and of this photograph the heliographical copper-plate is made. On an average, it may be assumed that by an experienced draughtsman one degree map-sheet in 1 : 60,000, quite black, will be finished in ten months. In the execution, however, the lettering and horizontal net is made by one and the drawing of the relief by another draughtsman.

II GROUP.

This is charged with the technical reproduction of the maps and with the execution of all the trials (*Versuche*) and other technical operations in that respect. It consists of one higher technical official as chief of

the group, and 2 subordinate technical superior officials as chiefs of divisions, and of the required number of officials and other technical assistants and non-commissioned officers for the manipulations.

a. Presses and book-binding.—This division is under a technical superior official, who is its chief, and employs 100 persons, who are partly steadily employed (have a fixed appointment) and partly employed by contract. Two steam (*schnell*) and hand presses are busy almost without interruption, with which there are produced annually 625,000 prints, of which the lithographic prints are proportioned to the copper prints as 11 to 1.

b. Galvano-plastic.—This is under a subofficial as master, directly under the chief of the group, and occupies 22 individuals, who are partly on a fixed salary, and partly non-commissioned officers assigned to this work. It has to cover the heliographically-produced copper-plates with a thin layer of steel, for the purpose of making it more durable in case of need to multiply the same, and to galvanically fill out with copper those parts of the completed copper-plates within which alterations or corrections occur, so that in those places the requisite additions and corrections can be made by the copper-engraver. In the course of one year there are about 600 high and low relief plates of different sizes prepared here.

c. Photography.—This division is charged with the multiplication of the topographical surveys, drawings, and other similar originals (*Vorlagen*) by making extended use of—

Silver-photography, (when the want of copies of the military-survey sections is limited;)

Photography in printers' ink or coal, (to make permanent copies of the survey-sections for special purposes;)

Photolithography, (for the reproduction of such maps and plans, mostly surroundings, (*Uingebungspläne,*) which are not subject to a correction, and must be made ready in the shortest possible time;)

Heliogravure*, (for maps which are intended for continuous use and must be kept corrected.)

Besides these, in rare cases use is made of coal-photography and chromolithography. The kind of reproduction is dependent also on the state of the original and the requirements to be made of the same. Under the direction of a superior official there are annually produced by 40 officials and non-commissioned officers about 1,700 photographical glass-negatives for copies on paper, partly for transfers on stone, copper, and zinc; nearly 5,700 photographical silver copies, for immediate want; 1,500 degree-map sections as unchangeable photography in coal, for use of the army in the field; nearly 100 photographic copies (*pausen*) on stone, for lithographic engraving, and nearly 240 heliographic plates for the special map.

6. MAP CORRECTION AND REVISION.

A special correcting office in charge of a staff-officer attends to the addition of all changes in the railroads, as also in new or altered roads, &c., which they have to add to the original survey-sections, as also to the original map-drawings, and then turns over the corrections made to the lithographic and copper-engraving division for correcting the

* By this process, which is still a state secret, a copper-plate is within six weeks obtained directly from the black drawing, so that it is ready for the print with the copper-printing press. The first work produced by heliography is the general map of Central Europe, which is prepared by the print of two plates, (one for the skeleton, the other for the ground, terrain.) For the saving of time and expense, it is reprinted on stone for publication.

stones and plates. The corrected prints are again sent back to the correcting office for approval or renewed correction. Two officers and four technical officials are employed here. For the revision of the original drawings of the special map there are employed, in addition, five officers to revise the maps drawn in the topographical division, especially with reference to the correct application of the conventional signs and of nomenclature, previous to their transfer to the reproducing division.

7. ARCHIVES AND LIBRARY.

This division is charged with the acquisition, collection, and deposition of all new book and map works of interest in this connection, (*einschlägig;*) also, with the delivery of the same to the different divisions for reference, (*Dienst-gebranch;*) with the exchange of home publications with those of foreign states; the acquisition, testing, and delivery of the instruments for triangulation and topography; with the testing of the aneroids coming into use, and the preparation of the respective tables of corrections; the presentation of the results of the examination of new instruments and apparatus; the compilation of the annual reports on the work done by the institute. It consists of one staff-officer as chief, two officers, two non-commissioned officers, and one army servant.

8. CONSUMPTION OF MAPS.

Besides the different book and art establishments home and foreign, which are charged with the disposal of the maps produced by the Institute, the Institute has a depot of its own in the city, where the maps can be obtained by everybody. This depot is in charge of a captain, who has one non-commissioned officer and one servant for the manipulations assigned to him.

9. MANAGEMENT AND ACCOUNT OFFICE.

The cash-account (*Cassa-Geschäft*) and the management are conducted by commissions specially formed for this purpose from the employés (*Personalstande*) of the Institute. Each of the commissions is composed of three members, viz: the cash-commission, of the director of the Institute as president, and two staff-officers; the commission of management, of a staff-officer as president; besides, of a captain and the director of the account-office.

The latter is the economic-administrative adviser of the director of the Institute as well as of the commission of management.

The cash-commission is charged with the disposition of the money in gross; and to conduct the cash-business in the daily and small affairs, a cashier's office is set apart, which is superintended by a captain.

The commission of management is charged, subject to the approval of the director of the Institute, with providing the Institute with all requisites, as money, materials, &c., and with the sale of the products of the Institute.

The account-office, subject to special instructions in regard to accounts and to demeanor, (*Gebehrung,*) performs the service of book-keeping, in a mercantile sense, and is therefore also to be looked upon, together with the office for state property, as an economic-administrative executive organ of the director of the Institute and of the commission of management.

It consists of a captain-account-keeper as director of the office, of two lieutenants-account-keepers, six accounts-assistants, and three clerks.

10. NON-COMMISSIONED OFFICERS' DIVISION.

Similar to the officers' drawing division, there also exists a division composed of forty well-behaved and sufficiently advanced non-commissioned officers or soldiers of the K. K. army, in charge of a captain, who are here instructed in lettering and the representation of the ground and relief, and prepared for their future employment in different divisions of the Institute.

Concerning the representation of the objects, the key to the conventional signs (*Situations-Zeichnungs-Schlüssel*) adopted for the topographical divisions is added in the appendix, and the further explanations of the manner of representation of the published maps is shown on each of them.

In regard to the samples of maps, it is further remarked that every year in July, the newest products of the Institute are sent through the K. K. Imperial War Department and the K. K. Ministry of the Exterior to the Smithsonian Institute in Washington.

The salaries (*Personal Dezüge*) of the persons employed in the different divisions of the Institute, and the expenditure of materials, are shown in the annexed statements.

K. K. GEOGRAPHICAL INSTITUTE.

Statement showing the amount of money expended in one year for writing and drawing materials, chemicals, paper, and instruments, &c., and of the expenditures for management and other purposes:

	Amounts in Austrian currency.	
	Fl.	*Kr.*
In the Institute itself	69,000	.....
For the triangulation	20,600	.....
For the production of maps	34,500	.....
Total	124,100	.....

Authority.—A manuscript memoir furnished by the Austrian government. (Translated by F. W. Lehnartz.)

CHAPTER V.

§ Notes on Italian Geodetic and Topographic Surveys.

CHARTOGRAPHY FROM 1815 TO 1861.

In this period of considerable length we have few copies of real Italian topographical works to be proud of. The principal maps of the Italian territory belong to Austria, which certainly was interested in having a detailed and correct topographical chart of Italy. But if Austria initiated it in the more important works of Italy, and in the greater part of the best publications, it is not less true that the greater part of this merit is due to their scientists, who belonged to the flourishing "Deposito di Guerra" of Milan, re-organized when the Austrians took possession of Lombardo-Venetia as the "Istitute Geografico," and remained in the metropolis of Lombardy till the year 1839, after which it was transferred to Vienna, and enlarged, became that famous Geographical Institute so well known, in which Italian artists were always employed.

Still, the other states of Italy did not remain idle; some very precious work came to light, and more could have been done by Piedmont and Naples if the political events had not disturbed the minds and aims of all from the quiet work of science and art. However, hereafter we will enumerate what has been done on the Italian soil, not only from our initiative, but from the Austrian.

A. *Kingdom of Sardinia.*—Piedmont was not without topographical elements, but they were not published. They were gathered before the French revolution by the topographical body existing then. Probably they were the manuscripts used for the composition of a new edition of the map of Borgonio.

During the period of the French domination and of the fighting of that era, the topographical works were suspended entirely; the Senate and Government retired to the isle of Sardinia.

In that period of time some copies were executed by the French and Austrian officers, but they naturally remained in their hands.

Suddenly, after the return to Turin of the House of Savoy in 1815, the continuation of a general map of the kingdom was ordered. And though the work for the grand triangulation was not resumed, yet they began the topographical survey. The two Riviere, the Canavese, the Monferrato, the county of Nizza were surveyed, part with the plane-table and part with the compass. Afterward they found themselves without means, and thought of using the cadastral maps for all the other provinces where the tax-maps existed.

Those cadastral maps, reduced to the same scale and carefully inserted in the trigonometrical nets that were in progress, were examined and completed on the ground, but in the elevated region of the mountains those documents were also defective, and for them there is not correct topographical material, but only the results of a reconnaissance without instruments.

The work proceeded with assiduity and correctness, so that by the end of 1830 all the provinces of the country were run through, and the trigonometric nets extended all over its soil. Then they commenced the formation of the projected map on the scale of $\frac{1}{50000}$. This had to be composed of 94 sheets. The copies were drawn, in water-colors, in

the office of the staff, and the number of sheets was reduced to 91. The publication of so extensive an atlas lasted several years. In the mean time the army and the public administrations were left without a correct official topographical map, not being able to consider as such that of the royal engineer, Giuseppe Momo, constructed and published with old elements in 1819 on the scale of about $\frac{1}{284750}$. This map had too little detail, though well delineated and well printed. Therefore they thought of forming, by means of deductions from the data gathered, a chorographical map, on a scale of $\frac{1}{250000}$. The project was carried out, and between 1841 and 1851 the beautiful map of $\frac{1}{250000}$, in six sheets, engraved on copper, appeared. It is a very valuable document, notwithstanding the high mountains were not based upon correct data.

The topographical maps of $\frac{1}{50000}$ were then successively published, but by a simple lithographical method, in consequence of the lack of artists and the urgent demand for such documents. This publication began in 1851 and continued till 1870. The sheets, before being published, were corrected on the ground.

During this long period some other works and publications were carried on and completed. We will enumerate several of these topographical works.

In 1835 a survey on the $\frac{1}{10000}$ scale was undertaken of the maritime Alps, employing the pretorian plane-table and the stadia-telescope. The elevations were represented by horizontal curves. This work was continued for several years, till they accomplished the survey of all the county of Nizza. But, on account of lack of means, an order interposed in 1851 and suspended that work, as it was excessively expensive.

In the years 1854, 1855, and 1856 were made some surveys, on the scale of $\frac{1}{10000}$, in the vicinity of Fenestrelle, for the purpose of giving practice to the scholars of the staff-school. And in the year 1857–'58, with the same idea, and on the same scale, was executed the survey of a part of the high valley of the Stura.

In 1857 the survey of the territory between Casale, Alessandria, and Stradella was also begun on the scale of $\frac{1}{10000}$. This work was not all published.

With the same publications there is a chorographical map of the isle of Sardinia that has some merit. It is in two sheets, engraved on copper, and on the scale of $\frac{1}{250000}$. This beautiful map, based on a trigonometrical net, departing from two bases, measured—one at Cagliari, the other at Oristano—is the work of a private individual, General Alberto La Marmora, of whom we have already spoken. The map was given to the public in 1845, and it is the only existing one of any value of that island.

Among the publications of less value we will mention the beautiful map of the country surrounding Racconigi, comprising one sheet, engraved on copper, on the scale of $\frac{1}{50000}$, and the map of the territory of Saint Maurizio, also on copper, of one sheet, and on the scale of $\frac{1}{15000}$, and published in 1864.

B. *Lombardo-Venetia.*—One of the first maps published by the Geographical Institute of Milan was that of Milan and the surrounding country, on the scale of $\frac{1}{50000}$, engraved on copper, in four sheets. After this the military map was commenced, with a change of scale and system of representing the ground, on the scale of $\frac{1}{86400}$, (not with the meter as a unit, but with the Klafter of Vienna.) This was, and is today, a model of precision and of careful execution. The map was to comprehend Venetia-Lombardy, but was extended to the duchies of Parma and Modena, and, at last, to Tuscany, Lucca, and the Pontifical

States, (Central Italy.) It was made in separate sheets, that could be united, as they were all of the same scale and the same geodetic execution. The topography consisted of cadastral maps, reduced to the scale of $\frac{1}{28800}$, which harmonized with the maps based on military triangulation, which were rectified and completed on the ground. Then they were drawn again, being reduced to the scale of $\frac{1}{86400}$, and given to the engravers on copper, who produced those magnificent maps which are to-day admired by all who are versed in topography.

These maps have the following dates of publication:

1828—Map of the duchy of Parma, Piacenza, and Guastalla, in 9 sheets, on copper.

1833—Map of Venetia-Lombardy, in 42 sheets, on copper.

1839—Map of the duchy of Modena, in 9 sheets, on copper.

1851—Map of Central Italy, in 52 sheets, engraved on stone.

The first three were executed in Milan and the fourth in Vienna.

Another work of great importance was published in Milan through the exertions of this same institute. This was the atlas of the Adriatic Sea, designed and engraved on copper in the Military Geographical Institute of Milan, (begun in 1817 and finished in 1830.) This is a general hydrographical map, in two sheets, on the scale of $\frac{1}{500000}$, and also of thirty sheets of details, on the scale of $\frac{1}{175000}$, and with a collection of 100 views of the principal seaports. To the above-mentioned atlas was annexed a descriptive portion, with the following title: "Pilot for the Adriatic Sea, compiled under the direction of the Military Geographical Institute and of the I. R. general staff, by Captain Giacomo Marieni."

The Neapolitan officers co-operated in the maritime survey for the formation of this grand work for the Adriatic coast of the kingdom of Naples. This publication was received by the public as a prodigy of science and art.

C. *Duchies of Parma, Piacenza, and Guastalla.*—We have no originals to make mention of except the completion of the tax-maps in 1836 by the government of Maria Louisa.

D. *Duchy of Modena.*—The officers of Modena took part with the Austrians, not only in the triangulation but also in the topographical survey of the ground.

E. *Grand-Duchy of Tuscany.*—The cadastral survey of Tuscany began in 1819 and was completed in 1827, based upon the beautiful triangulation of the professor, Père Inghirami.

These cadastral maps served Père Inghirami as elements for the construction of a beautiful chorographical map of the Grand-Duchy, on the scale of $\frac{1}{200000}$. The maps were reduced and completed on the ground.

The map, based on geodetic nets of the author, and adorned with various indications, was engraved on copper, in four sheets, and published in 1830. The execution is admirable, and can compete with those of the Geographical Institute of Milan. This is the only original map that has been published by the Grand-Duchy of Tuscany in the present century.

F. *Pontifical States.*—The only original work of importance was the tax-map, on the scale of $\frac{1}{2000}$, finished in 1821.

We may also add the map of Rome and adjacent country, constructed and published upon geodetic work, by the engineers Conti and Calandrelli, of whom we have already spoken.

G. *Kingdom of the Two Sicilies.*—From the geodetic work above mentioned, we see that science, in spite of the many interruptions caused by political events, was not neglected in Naples.

Here we will note also that topography and the art of engraving were cultivated with particular care by the Neapolitan Topographical Office.

The topographical works and publications were numerous, but, for the most part, partial. Perhaps the means and circumstances prevented the completion of large works; perhaps, also, a sufficient impulse was wanting.

The project of a map of the kingdom, on the scale of $\frac{1}{80000}$, reduced from that of $\frac{1}{20000}$, was magnificent, but it was only commenced, and they were obliged to satisfy themselves with a general map, on the $\frac{1}{640000}$-scale, of the kingdom this side of the Faro, and with a map of Sicily, on the scale of $\frac{1}{260000}$, in four sheets.

The execution of the first sheets on the $\frac{1}{80000}$-scale was accomplished very accurately, scientifically, and splendidly by the skill of the designers and engravers; it is a sin that such a work was not completed.

In praise of the Topographical Office, which was the first and oldest institute of this kind established in Italy, we will enumerate some of the best works accomplished in this second part of the Italian topography:

First. The map of the provinces of Naples and a portion of the provinces of Caserta and Avellino, in fifteen sheets, engraved on copper, and on the scale of $\frac{1}{25000}$, commenced in 1819. This beautiful work of publication ought to have been extended to the kingdom of Naples; but the plan was changed, and a partial map was constructed for the above-mentioned regions, suspending further works.

Second. The plan of the city of Naples and the surrounding country, in one sheet, engraved on copper, on the scale of $\frac{1}{7675}$, published in 1828.

Third. The plan of the city and port of Trapani, in one sheet, engraved on copper, on the scale of $\frac{1}{2500}$, published in 1839.

Fourth. The plan of the city of Palermo and surrounding country, in four sheets, engraved on copper, on the scale of $\frac{1}{5000}$, and that in one sheet on the scale of $\frac{1}{9110}$, published in 1818.

Fifth. The plan of the city and Strait of Messina, in one sheet, on copper, on the scale of $\frac{1}{30000}$, published in 1832.

Sixth. Map of the shore of the river Tronto to the Cape Saint Maria di Leuca; atlas in thirteen sheets, engraved on copper, scale $\frac{1}{100000}$, published in 1834.

Also, many maps of maritime cities and foreign sea-ports.

ITALIAN CARTOGRAPHY FROM 1860 TO 1875.

GEODETIC WORKS.

At the beginning of the new kingdom of Italy the need of a general topographical map was felt, on a scale large enough to serve with profit to the army, and to be used by the administration of the kingdom and by private individuals. The proportion of 1 to 50,000 seemed the most appropriate, except for interesting regions, where, for one reason or another, it was necessary to use a larger scale.

We have already seen, in the progress of this article, what general topographical maps existed in the single states of which Italy was composed, so that we do not need to enumerate them again.

Nevertheless, we will sum them up:

1st. The map of the provinces of the kingdom of Sardinia, on the scale of $\frac{1}{50000}$, in progress of publication, and the reduced one, on the scale of $\frac{1}{250000}$.

2d. The map of the isle of Sardinia, on the scale of $\frac{1}{250000}$.

3d. The Austrian maps, on the scale of $\frac{1}{86400}$, of Venetia-Lombardy, the duchies of Parma and Modena, and Central Italy.

4th. The map of Tuscany, by Inghirami, on the scale of $\frac{1}{200000}$.

5th. The map of the kingdom of Naples, by Rizzi Zannoni, on the scale of $\frac{1}{114942}$.

6th. The map of the isle of Sicily, on the scale of $\frac{1}{260000}$.

All these maps, except the first, were more or less ancient, of different scales, and such as did not satisfy all requirements. All were drawn with system and conventional signs, but they were not uniform. None were made on a regular plan throughout. Whilst, therefore, the maps numbered 1, 2, 3, and 4 represent clearly enough the details of the land, especially those of Piedmont and Austria, those numbered 5 and 6 were not completed, and were not susceptible of improvement. They were maps truly valuable for the epoch in which they were made; but the system of representation and the geodetic inaccuracy did not admit of correction.

In this state of things the Italian government decided to construct, first, a map of the Neapolitan provinces, and of the isle of Sicily; and a project for this purpose was presented to the parliament in 1861.

The geodetic work was begun in the same year in Sicily, basing the triangulation on the existing one in the province of Palermo. They had not time to measure a base, because they wished to furnish, as quickly as possible, the trigonometrical points to the topographers charged with the survey of the ground, reserving the correction of the primary triangulation until after the measurement of one or two bases which was to be made before ending the geodetic operations.

The instruments employed were repeating theodolites of Gambey and Ertel. The calculation was according to the formula of Puissant; the allowable error being $\pm 5''$ for triangles and $\frac{1}{15000}$ for distances.

While every one was proceeding to the execution of these works, an event happened which modified the adopted project, substituting more precise methods for observation and calculation.

General Baeyer, the dean of those versed in geodesy, proposed in 1861 to the Prussian government to invite the European governments to form an association for the purpose of undertaking in common the measurement of a portion of an arc of a meridian and of a parallel on a central zone of the European continent.

The Italian government and most of the states accepted the invitation of Prussia. Italy sent delegates to the convention, which assembled at Berlin between the 15th and 22d of October, 1864.

We will not insist on mentioning the agreements of the conference relative to the conditions which determined the operation destined to accomplish the scientific aim proposed. The agreements and reasons which dictated it are minutely described in the exact reports published at the end of each meeting of the conference. We shall limit ourselves to noting the new direction that this event gave to the Italian geodetic works.

The Italian commission met at Turin in June, 1865, and adopted the following resolutions:

The geodetic nets, for the measurement of the European degrees, will be three, and will spread along the lines of three meridians and of three parallels.

The directions selected were as follows:

(*a*) The first net will extend from Cagliari by the island of Corsica along the Tuscan shore to Genoa and Milan, extending across Switzerland, Western Germany, to Christiana.

(*b*) The second, starting from the island of Ponza, will be carried, by Rome, Florence, and Padua, to Munich, Leipsic, and Berlin.

(*c*) The third from Cape Passaro, the extreme southeast of Sicily, by Messina, Potenza, Foggia, and the island of Tremiti, will cross the Adriatic Sea and extend in Dalmatia to connect with the Austrian nets, stretching by Vienna and Prague to the Baltic Sea.

The three nets along the parallel circle are the following:

(*d*) The first from the frontier of Savoy, extending to Padua, following the middle parallel already mentioned, from Bordeaux to Fiume.

(*e*) The second will commence in Corsica, extend to Gargano, and pass to the Dalmatian shore.

(*f*) Third, from the island of Ponza to Brindisi.

The practicability of connecting Sicily with Africa by means of geodetic operations was considered; of remeasuring the meridional net of P. Beccaria between Mondovi and Andrate, and finally of establishing a net of triangles in the longitudinal direction of the Italian peninsula, as much for the purpose of connecting the already-mentioned nets, as for the eventual measurement of oblique arcs.

It was determined that the nets should be double, that is to say, formed by connecting polygons for the purpose of determining equations of condition for the computation of compensation.

As a matter of convenience, it was determined that, for each series of 20 to 25 triangles a base should be measured with great care, in order to serve as a check, and they were located at the following points as most suitable: Trapani, Catania, Taranto, Foggia, Rome, Rimini, Leghorn, Somma, Turin, and Cagliari.

It was proposed to employ the reiterating circle, for observation of angles, supplied with microscopes of such power as to be able to read to 1″ or 2″, without excluding the use of the repeating theodolite.

For the determination of heights it was decided to employ the method of reciprocal observations.

In the computation of the geodetic nets, it was decided to employ the formula of Bessel, and to use logarithmic tables of ten decimals to keep account of angles to the hundredth of a second, and of distances to the hundredth, and in the calculation of compensation to go to thousandths.

The computations had to be made by polygons composed of such a number of triangles that in the progress of the computations they would not be obliged to solve more than thirty equations. The elements of the perimeter, common to two contiguous polygons, had, besides, to satisfy conditions of geometry, taking an absolute value: (*a*) for angles, the mean of the single result given for the adjustment of the two polygons; (*b*) for the relation of the sides, in the same way, the mean value; (*c*) for the absolute length, the value deduced from two or three nearer bases, assigning, nevertheless, to each base a weight depending on its proximity and on the probable error in its measurement.

We have thought it convenient to indicate in a concise way the form above mentioned, to give an idea clear enough of the geodetic works of the first order which Italy is in the way of executing, and of the precision which is aimed at.

We shall say only a few words in regard to the astronomical works, enough to indicate their connection with the geodetic operations.

It was ordered that the places to be determined astronomically should be—

1st. The existing astronomical observatories, (there are, large and small together, about 20.)

2d. A certain number of stations at the points of conjunction of the geodetic meridian nets with the parallel.

3d. The stations or places where it has been found or it is believed there are anomalies in regard to the intensity of the force of gravity.

For such a purpose, in regard to latitude, it was decided—

(*a*) To establish observatories on the meridian of Cagliari, in one or two places on the island of Sardinia; one or two in Corsica; one in the island of Elba, at Pisa, at Genoa, at Tortona, at Pavia, at Milan, and at a point on the Swiss frontier.

(*b*) On the meridian of Ponza, observation of the latitude of Ponza, Rome, Naples, Montefiascone, Perugia, Florence, Rimini, Bologna.

(*c*) On the meridian of Cape Passaro, observation of latitude of Cape Passaro, Catania, Messina, Cosenza, Potenza, and Foggia.

(*d*) On the short meridian of Turin, considering the excessive local attraction, the latitude of San Remo will be determined, from a point to be selected on the Apennines, also the latitude of Mondovi, Sanfré, Saluzzo, Turin, Massi, Andrate.

The longitudes to be determined are—

(*e*) On the middle parallel, and in consideration of the fact that in the valley of the Po there are many local attractions, there will be determined with electric apparatus the differences of longitude between Geneva and Mont Cénis, between Mont Cénis and Turin, between Turin and Milan, between Milan and Padua. It was also thought that it would be useful to insert other determinations by means of fire-signals, and by means of chronometric expeditions.

(*f*) On the parallel Ajaccio Gargano, the differences of longitude between Ajaccio and the island of Elba, between this and Rome, and between Rome and the Gargano.

(*g*) On the parallel of Ponza-Brindisi, the differences of longitude between Ponza and Naples, between Naples and Potenza, and between Potenza and Brindisi.

It has been ordered since that the determination of azimuth ought to be made:

1st. In all astronomical observatories.

2d. At all astronomical stations situated at the intersection of the geodetic meridian nets with those of the parallels.

3d. At all places where it was thought that such a determination could throw light on the nature of local observations.

4th. At several points of Calabria and of the north shore of Sicily, on the hypothesis that the connection between Sicily and Africa would be effected.

5th. At the extreme points of the meridian arcs and of the parallels above mentioned, viz, Cagliari, Ponza, Brindisi, Cape Passaro, &c.

Together the number of points to be astronomically determined would be about 60. It was determined to connect with greater care the existing observatories and the astronomical stations of the country with the geodetic nets.

The geodetic work has been continued in Italy since 1865 on the plan indicated by the international commission. Although circumstances have allowed only a small number of operators to be employed in the field and in the computations, nevertheless a considerable part of the programme has been completed.

The arc of the meridian between Cape Passaro and Dalmatia of 6° has been observed, calculated, and adjusted; and the crossing of the Adriatic has been completed in connection with the Austrians, between the Gargano and Dalmatia, and between Terra d'Otranto and Albania.

They measured the bases of Naples, of Catania, at the mouth of the river Crati, of Lecce, and in the spring of 1873 a base near Udine was measured by the Italian and Austrian officers, each one using his own apparatus for the purpose of comparing the results obtained and the value of each apparatus.

The sheet published on the scale of $\frac{1}{3000000}$ gives a clear idea of the triangulation of the first order executed in the southern provinces of Italy.

On examining this map it can be seen that the meridian net from Cape Passaro to Dalmatia was observed and subjected to the calculation of compensation. The difference in the lines with which the triangles are covered shows the different portions into which the total net has been subdivided in order to subject it to the calculation of compensation, without having a great number of normal equations to solve.

1st. Starting from the south and going towards the north one can see the Sicilian net extending from Renna-Mezzogregorio to Santa Croce-Sant'Angelo di Patti, Sant'Angelo di Patti-Tre Fontane. This net comprises 29 triangles of 30 to 40 kilometers to the side, beside a chain of 12 triangles from the base of Catania and extending to the side of first order Monte-Rossi-Perrière.

In this first work were used partly repeating instruments; this is the cause of the mean error exceeding two or three tenths of a second.

The instruments which were used for such operations are a 10-inch Gambey theodolite, a 12-inch Reichenbach theodolite, an 8-inch Gambey theodolite, a 10-inch universal instrument of Pistor & Martins, an 8-inch universal instrument of Pistor & Martins. The first three were repeating, the last two reiterating.

It will be observed that the western part of Sicily has a net of triangles not subject to the calculations of compensation.

It is the portion of our triangulation that was executed between 1862 and 1864, resting upon the side of the old Neapolitan triangulation, the aim of which was only that of supplying data for the topographical surveys.

The high scientific purpose of measuring a terrestrial arc did not enter into the works executed before the formation of the commission.

This work, however, will soon be resumed, to make all convenient corrections, and some time it will unite Sicily to Africa by Cape Bon, which operation, as a consequence, cannot be avoided.

2d. There are to be formed the nets between Sicily and Calabria from the side of Santa Croce-Sant'Angelo di Patti, Sant'Angelo di Patti-Tre Fontane, to the side Montea-Serra Castellara, Serra Castellara-Cozzo Sordillo, Cozzo Sordillo-Capo Trionto.

This net presents 27 triangles comprised in the general compensation and three independent ones.

The mean error of each direction deduced from the compensation, is

$$0''.815 \pm 0''.045$$

The instruments which we have used are a 10-inch repeating theodolite of Gambey; reiterating theodolite of Repsold, 10-inch; Starke, 10-inch; Pistor, 10-inch; Pistor, 8-inch.

The nets mentioned present sides whose length is exceptional in our operations; these are the sides of triangles which unite Sicily to the continent, crossing the sea, touching the island of Ionia. The longest side is Stromboli-Montea; this is 120 kilometers.

In spite of the exceptional condition of this triangulation the results of its comparison with that of Sicily were very satisfactory.

The triangulation between Calabria and Sicily, supported on the base of Crati, is interesting in the harmony of the connection of the triangulation, that is of the sides Santa Croce-Sant'Angelo, Sant'Angelo-Tre-Fontane. The difference between the logarithms of these sides, given by the two triangulations does not exceed 72 units of the seventh order, which is equivalent to a small difference of $\frac{1}{600}$ in the length of the sides.

3d. The triangulation between Calabria and Basilicata presents the following data: 25 compensating triangles, 8 triangles outside of the compensation net, 7 formed with directions already compensated and out of the nets here considered.

Mean error in all directions,

$$0''.376 \pm 0.019.$$

The instruments used were of Pistor, Repsold & Starke, each of 10-inch limb.

4th. The net of Basilicata comprises 25 triangles included in the general compensation, and 3 independent triangles. This net starts from the side of the triangulation between Calabria and Basilicata, Giagola-Alpi, Alpi-Nocara, and falls on the side of Puglia Biccari-Ascoli, Cerignola-Torre Pietre.

Mean error in all directions.

$$0''.485 \pm 0.025.$$

Instruments: Repsold and Starke, of 10-inch limb.

5th. Net between Puglia and Dalmatia. This is united to that of Basilicata by the already-mentioned sides, and crosses the Adriatic, touching the islands of Tremiti and Lissa, and unites in Dalmatia with the Austrian nets.

Number of triangles forming system of compensation, 30; and 8 independent ones.

Mean error of each direction,

$$0''.683 \pm 0''.035.$$

Instruments: Reichenbach, 12-inch, (reapeating;) Pistor, Starke and Repsold, 10-inch, (reiterating.)

The triangulations of Puglia and Basilicata are supported on the base of Foggia. They connect with the triangulation of Crati on the sides of Alpi-Bulgaria, Alpi-Nocara.

The difference is of 14 units decimals of seventh order in the logarithms of the common sides; that is to say, that the error which is to be feared on the sides does not surpass the $\frac{1}{250000}$ of their length, a result very satisfactory.

Now we think it will be very interesting to say something on the measure of the bases.

The apparatus which we used was constructed by Ertel, of Munich, on the plan of that of Bessel.

We shall not stop to consider the illustrious scientist's method of measurement, but the following figures will certainly show the high grade of precision attained by us.

1st. Base of Catania: length 1,894 toises, with a mean error of 1 line and 22 hundredths.

2d. Base of Crati: length 1,497 toises, with a mean error of one 1 line and 984 thousandths.

3d. Base of Lecce: length 1,560 toises, with a mean error of 1 line.

4th. Base of Undine: this base, whose definite value has not yet been calculated, was, as we have said before, measured in the spring of 1873 by Italian and Austrian officers with their own apparatus.

The harmony between the measurement and remeasurement of the Italians was much greater than could have been expected, and an absolute agreement has been ascertained between the Austrian and Italian results.

It is easy to understand the advantage of this comparison of measurements and the results that may be deduced for the comparison of the triangulation of the two states and for the equalization of their measurements.

This would be the place to speak of the results obtained in the operation of geodetic leveling, which was spoken of in the conference of 1864. But this category of operations has since received new direction by the Swiss scientists Hirsch and Plantamour, and the importance of geometrical levelings of precision has been recognized.

Italy intends to undertake as much as possible for the benefit of the works which place her in correlation with the countries which took the precedence in such operations.

We shall yet observe that the trigonometrical net on the parallel Brindisi-Ponza is almost entirely observed and will soon be also calculated; that five astronomical stations have been finished by determination of latitude and azimuth, that is to say, those of Naples, Monte Mario, Termoli, Lecce and Potenza; that they have telegraphically determined the difference of longitude between Palermo, Naples, and Rome; between Milan, Simplon, and Neufchatel; between Milan, Padua, Genoa, and Naples.

All the geodetical and astronomical work, done with the aim of measuring terrestrial arcs, will form the subject of scientific publications; and there are now in progress of publication several accounts concerning our measure of bases, and the determination of difference of longitude of Milan, of Simplon, and Neufchatel. That of the observations on latitude and azimuth at Lecce exist already.

Already, by the diligence of the observatory of Naples, reasons and results of analogous operations made between the observatories of Rome, Naples, and Palermo have been published.

At the same time that they were working to execute the grand net for the measure of the European degree, the works to determine the trigonometrical nets were actuated by the aim to furnish the necessary bases to the geographers.

It was ordered to determine a trigonometric point for each 25 square kilometers.

The geodetic work has been continued and will still be carried on for some years, in connection with the astronomical measure of the degree in Europe, and the results, in view of the precision with which they have been carried on up to this time, cannot be less splendid.

In the current geodetic campaign (1875) operations are being carried on in the Tuscan and Ligurian Appenines, and various astronomical stations are being occupied, which pertain to the measure of a degree in Middle and Lower Italy.

TOPOGRAPHICAL WORKS AND PUBLISHED MAPS.

The unity of Italy has been of great benefit to the national topography and cartography. The Italian Staff took all the topographical elements scattered in the different states of Italy, superintending them all except that of Naples, which was preserved as a section of the superior office, and thence of the technical office of the staff of the army, because, possessing an observatory, good geodetic instruments, able operators and

artists, under a sky so favorable to observations, it could bring, as in fact it did, usefulness and dignity to science and art. This is the period of the true Italian National Cartography.

Soon after the first annexations of 1859, the government felt the need of a general map of all the provinces of Middle and High Italy recently annexed; and as the time was short, it was thought best to take the existing materials, in order to compile it quicker. Therefore the well-known cartographic map was issued, on the scale of $\frac{1}{600000}$, of Upper and Central Italy, in 6 sheets, engraved on copper, and finished in 1864. For the first 4 sheets were used the plates of the chorographic map of the Alps, together with the work "Le Alpi che cingono l'Italia." For the fifth sheet they made the most of the map of the island of Sardinia, by General Alberto La Marmora; and for the sixth, a reduction of the corresponding part of the Austrian map, on the scale of $\frac{1}{864000}$, was made. They were at first on copper plates, and in reductions the principal variations found in topography and in the systems of roads and hydraulics of the countries were represented.

We have previously stated how, after the annexation of Naples and Sicily, it was of supreme necessity to give as soon as possible to the army and to the administration a map of the southern provinces of Italy and Sicily.

It was not possible to wait for the completion of the beautiful Neapolitan map, on the scale of $\frac{1}{80000}$, which was being engraved on copper in the Topographical Office of Naples; and those existing of Rizzi-Zannoni and of the island of Sicily (this last compiled from the works of Captain Smyth, of the English navy) were too old and were based on geodetic elements rather incorrect, although for artistic execution they could be called admirable for the time in which they were published.

Soon after the beginning of the geodetic work of which we spoke in the previous chapter, the topographers went to work in Sicily and took the plan of the ground. The scale chosen was that of $\frac{1}{50000}$, a bold innovation, which, nevertheless, in fact, succeeded very well. The survey was made with a plane-table and perfected telescope, which did not leave anything to be wished. All the graphical points of our field-work were determined by intersection or by the stadia, and were plotted, an operation which has rendered very easy the tracing with precision the equidistant horizontal curves for every 10 meters elevation.

The survey of the isle of Sicily, commenced in 1862, was finished in 1868.

Field sketches neatly copied in the office could be reproduced. They were in fact reproduced by photography and the heliotype process, and became valuable to those who required such. They truly represented the exact drawing of the ground, and the engineers, engravers, and technical men found in them elements necessary for a new process.

The need of the state and the continual advancement of every man that becomes known inspires scientific genius, artistical and mechanical. It was truly the exigencies of the epoch and of the land, in which and for which he lived, that inspired Colonel Avet, of the Staff Corps; he discovered by profound and continuous study a wonderful process of reproduction, viz, photoincision

It was wished to give immediately to the scientific world a great proof of this process of reproduction, and the map of Sicily was reproduced in the brief period of two years, reducing it to the scale of $\frac{1}{100000}$ in 48 sheets, and reducing it from the originals of $\frac{1}{50000}$, neatly copied. We have possessed it since 1871.

Hardly were the topographical works of the island finished, when they

passed to the survey of the Neapolitan provinces on the same scale of $\frac{1}{50000}$, with more careful instruction to the topographers, and therefore with always greater perfection, so that they no longer needed a neat copy of the field-sheets, for the necessary reproduction of the topographical works a few days after having finished the survey of the country.

Photography and the heliotype process comprised at first the methods of immediate reproduction. But afterwards a new and fine invention improved it greatly. We speak of photolithography, a perfected process, taught and introduced by Colonel Castelli, of military fame.

Photographs reproduced and engraved on copper by a chemical and mechanical process, which is the inventor's secret, furnish us magnificent engravings.

Photographs transferred on stone and on zinc give us the means of reproducing in a short time any drawing.

To-day is given an original work to be photoincised, and after a month the sheet can be given to the trade, comparing favorably with the handsomest engraving on copper.

Photography is yet more rapid, and furnishes to the public (like zincography) the drawings reproduced after two or three days, and they are good enough to be used in war and by technical men.

The topographical works in the southern provinces of Italy will be terminated in the current year. The map composed from this survey will consist of 174 sheets, (348 half-sheets.) Until the present time all work executed in the country, up to the year 1874, has been reproduced by photolithography and by photozincography. The field-sheets which will be finished this year will be reproduced and given to the trade in the spring of the coming year, 1876.

Meanwhile the government thinks already of extending the survey to the other provinces of the kingdom in order to obtain a map on a large scale complete, uniform, detailed, and recent, of all Italy. But for the present, in order to make the map of Piedmont useful in 91 sheets, which is constructed on the same scale of 1 : 50,000, as it is in some respects valuable, and above all the only one existing on a large scale, they begun the correction of the stones, executing them after a careful local reconnaissance perfected by the officers attached to the Military Topographical Institute. Twenty-seven sheets have been corrected; also the chorographic map of Upper and Central Italy on the scale of 1 : 600000 is in progress of correction, and at this time two sheets have been rectified.

Here it would be well to mention the notable change which happened in the organization of the technical office which has acted as part of the staff corps since the year 1872. The considerable development of the geodetic and topographical works induced the Government to dissolve the technical office of the staff of the army, transforming it radically under the denomination Topographical Military Institute, with independent action and self-control.

The Institute began work January 1, 1873. All the works already mentioned have progressed with rapidity under the new direction with more ease and less trouble.

Besides the above-mentioned works the Institute proceeded to the survey of the vicinity of Florence and Rome, and other special locations, on the scale of 1 : 25000 and of 1 : 10000, successively reproduced by photolithography and chromolithography, and above all to the drawing and reproduction, by means of the photoincision of Avet, of a chorographic map, of 25 sheets, of the Neapolitan provinces, on the scale of 1 : 250000, reducing it from the Austrian elements found in the topographical office of Naples. These elements, on the scale of 1 : 103680, composing a map

of the Neapolitan provinces put together between 1821 and 1824, in the time of the Austrian usurpation, were copied on the scale of 1 : 125000, introducing all the corrections to the roads and hydraulic systems, and representing the mountains with the line of vertical light. These drawings, in fair hand, on the scale of 1 : 125000, were successively photoincised on the scale of 1 : 250000, (the last seven sheets in the spring of the current year,) and produced a good and fine map in many respects. So the southerly provinces of Italy, the poorest in modern maps, became all at once the richest and most advanced, thanks to the diligence of the staff and the activity of the topographical Institute.

The Institute executed in addition many maps on a large scale (1 : 5000 and 1 : 10000) for the study of war, and proceeded to a third edition, entirely revised, of the itinerary of the kingdom, adorned with a map of Italy, a chromolithograph on the scale of 1 : 1000000.

All these interesting and varied works were used in the production of a number of maps for the field exercises in 1873, '74, and '75, and many other works too numerous to mention.

But the thoughts and studies of the administration and of its scientific men and artists were involved in a greater, more durable, and definite work. We wish to speak of a general map of all Italy on the scale 1 : 100000, which was the last application of science to the construction of maps of topography. The proposition was presented to the House in order to obtain funds, and was passed. The new map will be formed of 287 sheets of the dimension of $0^m.41 \times 0^m.37$, and constructed on natural projection and based on the new and careful geodetic triangulation, the result of the great operation of the European degree measurements. The topography will by use of the plane-table give the most recent planimetric changes.

This map, the first sheets of which are already in progress, will certainly do credit to the art of Italian cartography, as well for execution as for correctness of details and beauty of reproduction.

FLORENCE, *July*, 1875.

Translated from Rivista Militare Italiana, Settembre, 1875.

§ 2. NOTES ON MAPS OF ITALY, PUBLISHED BY THE ITALIAN MILITARY TOPOGRAPHICAL INSTITUTE.

I. A map of the Kingdom of Italy, scale 1 : 1000000, to adorn the general itinerary, third edition, revised and corrected, 1875. This is a chromolithograph, printed on 6 sheets, $20'' \times 16''$, to be joined in one. The border is subdivided so as to show the latitude and longitude, but no meridians or parallels are drawn. The railroads and carriage-roads, the boundaries of states and provinces, and the principal rivers are given. The whole is a compilation from old and recent surveys, and only parts of it are based on accurate survey.

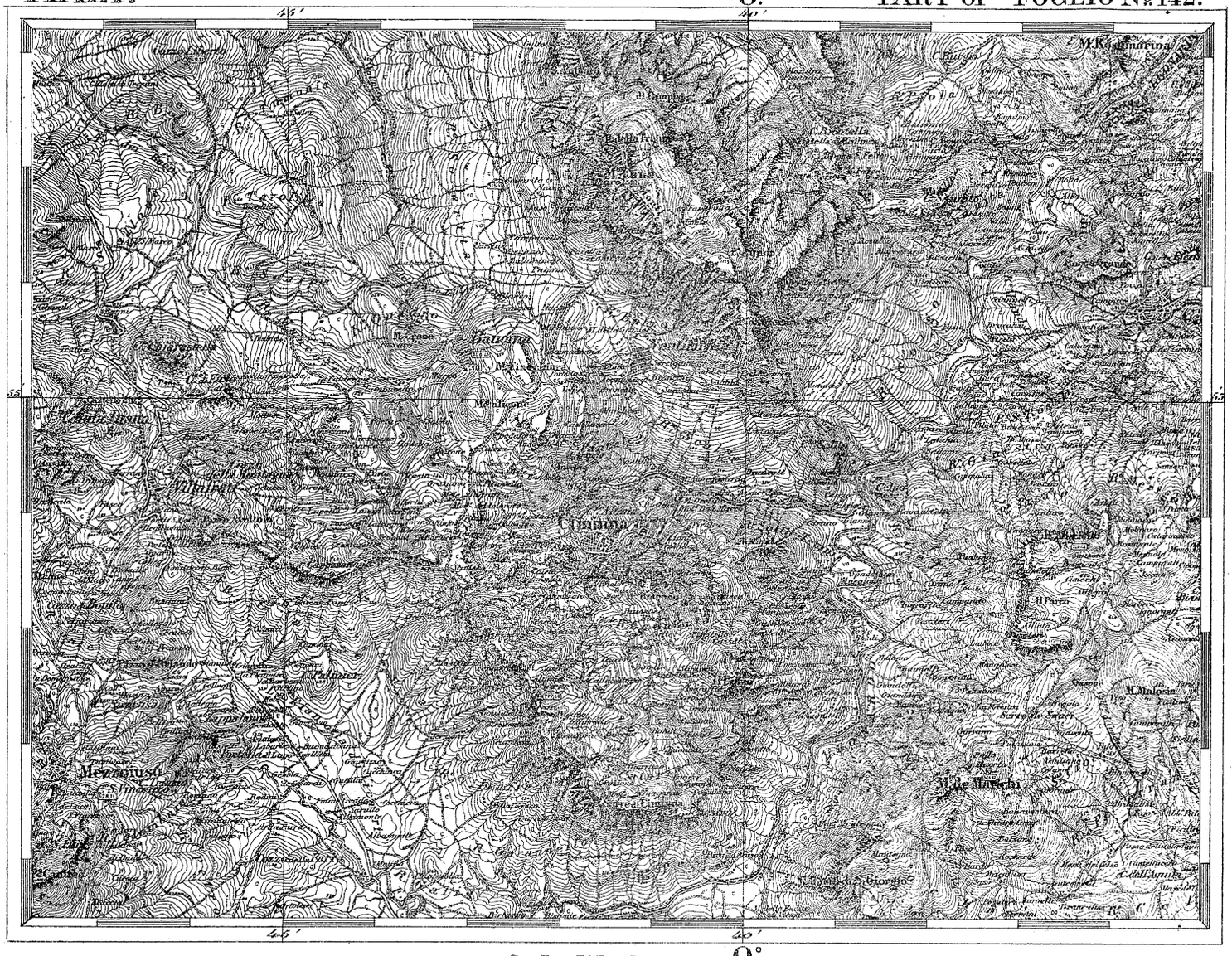
II. A topographical map of the province of Naples, scale 1 : 250000, published in 1874. This work, in 25 sheets, $13\frac{1}{2}'' \times 11\frac{1}{2}''$, was produced by a process called "Foto-incisione," and is a reduction from Austrian surveys, scale 1 : 103680, made between 1821 and 1824. This last survey was first reduced to the scale of 1 : 125000, and the reduction further reduced by foto-incisione.

The border gives the latitude and longitude to minutes, but no meridians or parallels are drawn. The principal lines of communication, the roads, water-courses, and boundaries of provinces are given. Relief is indicated by hachures drawn and reproduced, so as to give the map a

ITALY.

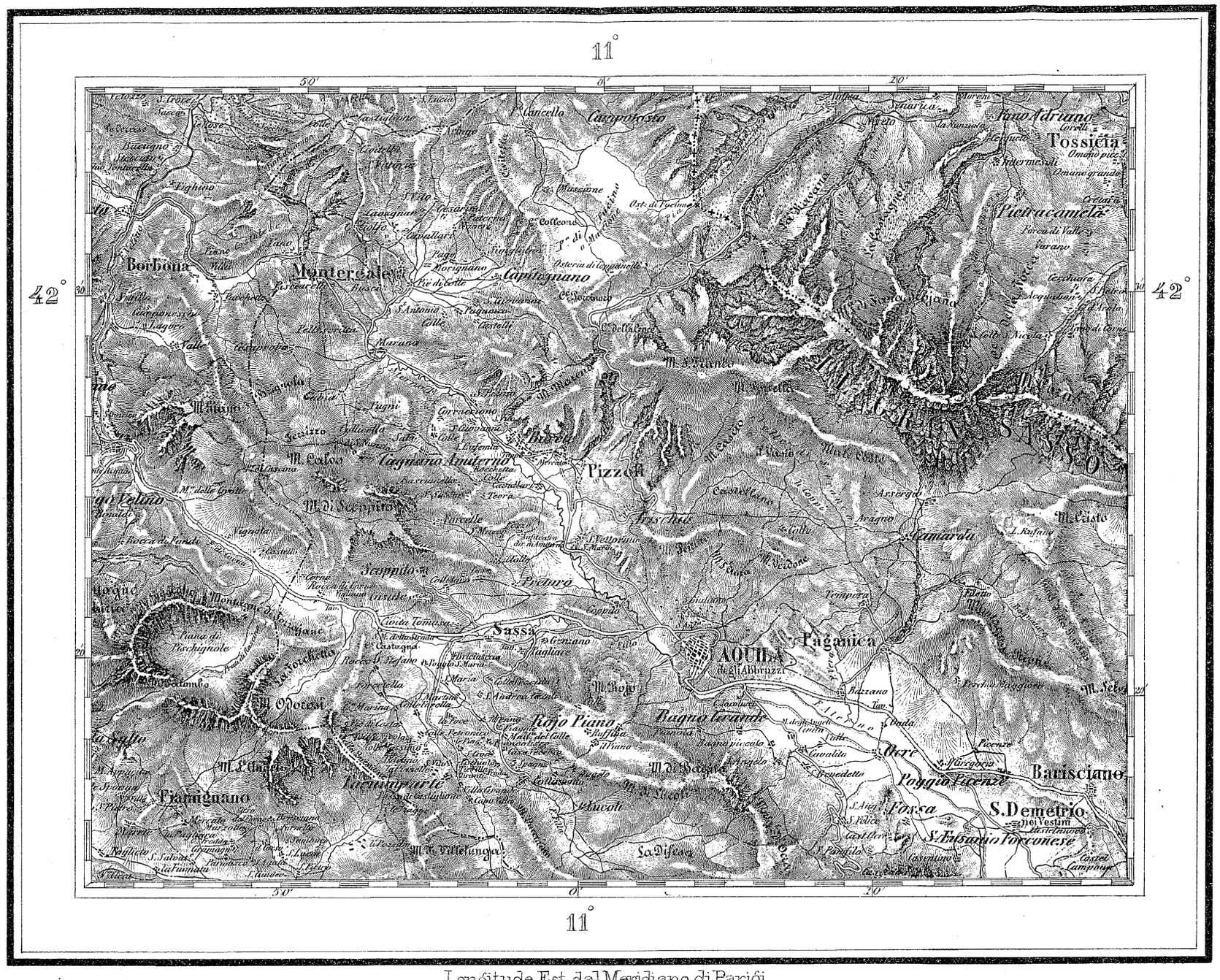
0°

PART OF "FOGLIO Nº142."



ITALY

Part of FOGLIO N° 1.



fine appearance. The method used for reproduction, foto-incisione, compares favorably with copper-plate engraving.

III. A topographical map of Sicily, scale 1 : 100000, published in 1871. This work consists of 48 sheets, $13\frac{1}{2}'' \times 9\frac{1}{2}''$, also reproduced by foto-incisione. The meridians and parallels are given for every five minutes, and references are made on each sheet to the adjoining sheets on each side. Relief is indicated by horizontal curves 10^m apart in elevation. Elevations are also given by figures at various points. The water courses, boundaries of provinces, railroads, and common roads, of second, third, and fourth classes, are indicated. Trees are denoted by a letter B, ("Fosco.") Cultivation of different kinds is also indicated by letters, as V, for vineyards, ("vigni;") G, for a garden, ("giardino.")

IV. A topographical map of the southern provinces of Italy, scale 1 : 50000. This is a reproduction by photolithograph and zincograph from the original field-sheets of the survey. The surveys for some of the sheets furnished were made in 1874. It is proposed to publish the same survey on a scale of 1 : 100000. Relief is indicated by contours for every 10^m of elevation, and figures are frequently given to show the height of prominent points. Numerous conventional signs are used to indicate railroads, and roads of first, second, third, and fourth classes, aqueducts and bridges. The nature of the ground, whether cultivated or uncultivated, marsh, meadow, brush, trees, vineyards, and rice-fields are all indicated by established conventional signs. This work when completed will consist of 174 sheets, (or 348 half-sheets,) $20'' \times 28''$; half-sheets, $20'' \times 14''$. The projection is made by Flamsteed's method, and meridians and parallels are given for every $5'$ of arc.

V. Map of Florence and vicinity, scale 1 : 25000, published 1875, one sheet $24'' \times 21''$. This is a photolithograph, shaded and colored. Latitude and longitude are not given, and no meridians or parallels are drawn. Relief is shown by contours for every 10 meters of elevation and by shading. Figures also give the elevation at various points. Conventional signs are used as in the previous case, (IV.) Houses are shown with the names of the proprietors in the surroundings of the city. Rivers and creeks are colored blue.

In the field-work for the recent surveys the plane-table and stadia were used for topography. Points for each sheet were furnished by the triangulation.

No information in regard to the organization of the "Italian Military Topographical Institute" or in regard to the details of their work is given, except the meager account in the "Rivista Militare Italiana."

Authorities.—Copies of maps.

Compiled by Capt. H. M. Adams, Corps of Engineers.

CHAPTER VI.

§ 1. State of the work of the Geographical Institute of Spain on the 31st of March, 1871.

GEODETIC WORK.

After the various reports of the geodetic work of the first order executed in Spain which have been published, the most convenient method of avoiding repetition and of conveying a clear idea of its actual state will be the recital of that which remains to be done in order to accomplish the plan projected by the government for the Geographical Institute, completing that which the old commission of maps traced out at the beginning of its work. Since the publication of the last of the abovementioned reports coincided with the turning over of this service to the Bureau of Statistics by decree of His Highness the Regent of the kingdom, on the 4th of January, 1870, it appears natural, in order that there may be no interruption of continuity, to refer to that which on that date remained to be done in order to complete the part projected, adding that accomplished up to the present date, as well as the new works, both of observation and of computation, which have been commenced.

To complete the angular observations belonging to the fundamental systems projected, (Plate VIII,) 102 vertices remained to be occupied, on 56 of which there were to be made, moreover, observations referring to the great quadrilaterals formed by the same systems, increasing to 143 the number of the stations, which were needed in the interior of those quadrilaterals of the first order.

In addition, it was necessary to verify various surveys in order to substitute with advantage several vertices selected but not observed, and to complete the general project of triangulation, as well as to prepare conveniently with signals or mounds of stone 97 vertices. Only one base had been measured for the net-work of the Peninsula, and it was therefore necessary to project the system of bases and to measure the additional ones, connecting them with the triangulation.

With regard to the computations, the first system of equations, formed from the data collected on each station considered independently, had been solved for all the vertices on which observations had been made; but no decision having been made as to the method to be adopted for the compensation of errors, and as to what should be the division, provided they were to be distributed in independent zones or divisions, the computations undertaken had been limited to this first part. The geographical coordinates of none of the vertices of the system had been determined, unless we except Madrid and San Fernando, whose latitudes and difference of longitude are known from their astronomical observatories. The azimuth of none of the sides was known with the necessary precision, since sufficient exactness was wanting in the approximate value of the side Madrid-Hierro, which had been determined with the assistance of the Madrid observatory from a very small number of observations in order to satisfy the most pressing necessities.

Lastly, it had been intended to run a special line of geodetic levels which should cross the Peninsula from the ocean to the Mediterranean, but the work had not been undertaken.

Of the vast triangulations of the second and third orders which have to cover the Spanish territory, only those belonging to the Balearic Islands were completed, and those of the provinces of Madrid, Toledo, and Guipuzcoa commenced.

Before proposing the completion of the general plan of geodetic operations, the Subdirector of Statistics, now the Director of the Geographical Institute, believed it convenient to mark the limits of the two groups, essentially distinct, which the triangulation of Spain embraces. The first comprises all those works which, serving as a basis for the others and circumscribing their errors, have besides as an object the advancement of science, by collecting new data for the more perfect knowledge of the form and dimensions of the earth, operations which demand in observation the most perfect instruments, materials, and methods, and in the computations of the results all the resources of mathematics. The second group embraces the triangulations of the different orders, designed for the graphic representation of the territory, and serving as a foundation for the topographical atlases which, for various objects, are needed by the public administration. In this work instruments more portable and of less accuracy are employed, the number of observations is reduced, and expeditious methods of computation are employed at the sacrifice of an exactness which is not absolutely necessary.

To the first group pertains the system of the ten fundamental series, the measured base and those which are to be measured in the future as the basis of the system, the determination of latitudes, longitudes, and azimuths on vertices conveniently selected, the investigations with respect to the force of gravity, and the special lines of precise leveling.

To the second group belong the triangulations of the first order which cover the interim of the great quadrilaterals formed by the fundamental series, and the geodetic net-works of the second and third order which depend upon the primary triangles and extend over the whole surface of the national territory.

Founded on that which precedes, it was proposed and approved by the Government—

1st. That the observations in the fundamental series should be continued preferably, following strictly the method which conduces to the compensation of errors by the formulas of Bessel and Baeyer, according to special instructions.

2d. That in addition to the central base, already measured, three others should be selected and measured, one of which should be situated, as already projected, in the most southern part of the Peninsula, and the other two as far north as possible, and near the eastern and western coasts.

3d. That the astronomical observatory of Madrid, concurrently with the Geographical Institute, and with due regard to the position of this scientific establishment, should commence the determination of latitudes, longitudes, and azimuths at vertices of the fundamental series conveniently chosen.

4th. That in the special leveling of precision the system agreed upon in the conferences of the International Geodetic Association for the measurement of degrees in Europe should be adopted, and that this new work should be begun immediately.

5th. That considering the fundamental series as a single system, the general compensation of errors should be commenced, solving the second group of equations which arise from the observations at each station considered independently.

6th. That the triangulations of the first order in the interior of the

quadrilaterals, and those of the second and third orders, should be commenced in each district according as they may be needed to support other trigonometrical net-works. To secure the surest execution of this plan and a convenient uniformity in all the work, the following measures were adopted: Four commissions, composed of chiefs and officers of the corps of artillery, engineers, and general staff, who are detailed to the section of geodetic works of the Geographical Institute, were charged with compiling projects of instructions; the first commission for the observation of angles in the geodetic triangulations of the first order, the second for the execution of the first computations which are to be made in the same triangulations, with all the necessary models, the third for the assistants charged with the construction of the signals of the first order, and the last for the service of the heliotrope sections. These projects of instructions being presented, they were approved and printed immediately.

Another commission, similarly formed, proposed the forms of computation to solve the equations and substitute the values of the unknown quantities, after they were determined, in the work which had been commenced for the general compensation; and these, having been approved, were also printed.

The representation of the net-work of primary triangles on a small scale, which had been engraved some years previously, being insufficient for planning the numerous equations of condition, and making the other preparatory studies, because it does not contain all the observed lines, another commission traced Plate VIII, on which, with the greatest clearness, is seen the actual state of the observations.

All the directions observed from each one of the stations are indicated, and it does not contain other lines which might cause confusion. The vertices selected, but on which no station has been made, remain without being united among themselves. The directions corresponding to the systems, which constitute the work of higher geodesy, are represented by full lines.

The directors of the observatory and Institute concurrently decided that the first-mentioned establishment should proceed at once to the determination of the azimuth of the side observatory, Hierro.

To a commission of chiefs and officers belonging to the same section was intrusted the study of the works published upon levelings of precision executed in other countries, and it was charged to present a project of the general basis upon which a double line of levels between the port of Alicante and the observatory of Madrid should depend. The commission executed its task, and after the proposed bases were approved the construction of the necessary instruments was ordered.

A place was required in which it would be possible to test the instruments by submitting them to conclusive experiments of measurement before undertaking the work, and a permanent geodetic observatory was established on the flat roof of a tower in the Madrid park, which was given for this purpose by the council. From the two pillars of granite, on which two instruments can be tested at the same time, five vertices of the fundamental series are seen; and it is therefore possible to carry out completely the same observations as on a geodetic station and to make comparative tests of the different instruments employed in the primary triangulation.

Finally, the geodetical assistants were organized into two divisions, and, in addition, an elementary theoretical class in charge of one of the military chiefs was formed, to which, during the suspension of the field-

work and in spare hours, is given the instruction necessary for the efficient discharge of the service confided to them.

A machine for executing with more rapidity and accuracy some of the numerical calculations was also procured.

The result of the field-work since June, 1870, has been, with respect to the fundamental series, the observation of the azimuthal directions and zenith-distances on 21 stations, 9 of which belong at the same time to quadrilaterals whose observations have also been made; the preparation with signals or stone mounds of 24 vertices; the repair of the constructions already made on 26 vertices; and the choice of 19 others belonging to the primary triangulation.

The astronomers of the Madrid observatory have made the observations necessary for determining the azimuth of the primary side—Observatory-Hierro.

In the province of Toledo, the reconnaissance for projecting the secondary triangulation, intrusted to the officers of the Corps of Topographical Engineers, has been continued; 84 vertices of the second order and 139 of the third having been selected, and the method of fixing 51 villages, which are not vertices of any of the triangles, having been prepared.

Special mention is deserved by that part of the office-work of the geodetic section, which has resulted in the resolution of the second group of equations for 94 vertices of the fundamental series, and in the solution of the first group for each one of the 21 stations occupied in the last season.

For beginning the work in April next, 9 parties, which are to continue the triangulation and commence the leveling of precision, are already prepared.

TOPOGRAPHICAL WORK.

In accordance with the order of his highness the Regent of the kingdom, in the decree of the 12th of September last, the director of the Geographical Institute formed the general plan for the topographical triangulation and the drawing of the field-sheets which are required for the publication of the map, for which the project was approved by the order of his highness, issued on the 30th of the same month, in which order it was also directed that the operations, with the extension permitted by the credits conceded by the Cortes, should be commenced immediately. This general plan of the works, in the compilation of which it was necessary to take into account the principal object which they had to satisfy; the services which they could lend successively to the different branches of the public administration; the state of advancement of the geodetic triangulations; the personnel and material of the institute, and the credit at its disposal, contains, among other things, the following directions:

"All the topographical works which are undertaken by this institute will have to be closely connected with the geodetic triangulation of the third order; but as this has been executed only in the Balearic Islands and the provinces of Madrid and Guipuzcoa, it is necessary to plan the operations in such a way that, without delaying until the geodetic triangulation covers a part of the territory determined upon, it may be possible to arrange in it a sufficient number of points of reference, trigonometrically situated, to complete later, and when the geodetic network has been further extended, the required connection between the geodetic triangles, which are the basis and foundations of the topo-

graphical representation and the works of detail undertaken to perfect this representation."

"To attain this object, it will be sufficient that the topographical sketches rest upon special triangulations, which in their turn can at the proper time be connected with the geodetic work of the third order. And it is not necessary that these topographical net-works should present that regularity which is generally required in the geodesy of the different orders; but, on the contrary, in consequence of their special objects, they may offer a mass of triangles of different forms and dimensions, some arranged in the form of a continuous net-work, others superposed, and nearly always without immediate relation with those of the adjacent triangulations. It is, however, important that the angles should be confined within convenient limits, and that from their vertices it may be easy to see the geodetic points, if there are such, or those points which it is probable will hereafter be made vertices of the general triangulation."

"Each of these partial triangulations must start from a short base, carefully measured by topographical methods."

"When the connection of the partial triangulations with the general geodesy of the third order has been accomplished, their azimuths will be determined, and the positions of their vertices can be calculated; but, in order that approximate azimuths may be had immediately, the necessary observations to determine its azimuth by the aid of Polaris will be made at one extremity of each base, using a theodolite which reads to ten seconds."

"At the same time that the horizontal and vertical angles are read on each vertex of the partial triangulation to the other vertices of the same, readings will also be taken to all the prominent objects of the surrounding country, such as towers, farm-houses, villages, mills, and boundary-marks, in order to connect this triangulation with the detail work."

"Each of the partial triangulations must cover the area of one or more municipal districts, and the length of the sides, which should average 2 kilometers, must not exceed 5. These triangulations will be made with repeating theodolites reading to ten seconds."

"The topographical surveys will be divided into two classes, the first of which will comprise the planimetry, and the second the hypsometry."

"The planimetry will embrace the drawing of the perimeter of each of the municipal districts at the time at which the survey is made, provided the land-marks have been set; the perimeters of the jurisdictional districts belonging to the same council, the topographic features, such as rivers, creeks, canals, roads, valleys, and groups of houses; lastly, the limits of the different kinds of cultivation whose area exceeds 10 hectares, (24.7 acres.) All these lines will be joined with the geodetic or topographical triangulation points by sights taken from the topographical stations of detail."

"The field-sketches will be drawn on a scale of $\frac{1}{25000}$, in order that the reductions which may be convenient may be afterward made."

"The second class of the topographical surveys will have as starting-points the special lines of levelings of precision and the altitudes of the geodetic vertices; as its sole object is the representation of the relief on a reduced scale, the operations will be limited to that which is strictly necessary for this special purpose. The second class will also comprehend the drawing of the topographical sketches of the towns which do not have them, but with no more details than are necessary for the publication of the map."

The general principles which precede, referring to the first class, received their complete development in some instructions compiled by

a commission, presided over, according to regulations, by the director of the Geographical Institute, and composed of four chiefs of the Corps of Topographical Engineers, numerous models, which should conduce to good order and uniformity, accompanying these instructions, which in autograph form are circulated among the persons charged with these new works.

It having been determined to commence the triangulations and topographical surveys in the province of Cordova, eight parties were sent there. Each party was composed of two officers and five topographers, who worked under the immediate orders of an officer of the corps in charge of all the surveys of the province.

In the four months from the end of November to the end of March, 553 vertices for the topographical net-work of triangles have been chosen, 22 bases have been measured, and their azimuths have been determined by observations on Polaris; 347 vertices have been occupied with the theodolite; the number of stations occupied with the compass reaches 52,967; and the number of kilometers measured amounts to 8,129, and, in addition, 50 boundary-lines between different municipal districts have been finished. These operations have completed the triangulations, now approved by the director of the Institute, of the districts of Cañete de las Torres, Doña Mencia, Zuhéros, Posadas, Aguilar, Morente, Fuente-Tójar, Encenàs reales, Monturque, Cárpio, Bujalance, Pedro-Abad, Zambra, Lucena, Montilla and Cabra, which cover an area of some 156,000 hectares.

The triangulations observed, but which have not been submitted for approval, cover an area of 35,000 hectares.

There have been examined in the Institute, previous to presenting them for approval, the topographical sketches of the districts of Monturgue, Posadas, Pedro-Abad, Morento, Carpio and Bujalance, which comprise an area of 52,000 hectares, in which the planimetry is finished, and in addition the same first period is completed in 116,000 hectares of the districts of Córdova, Lucena, Encenàs reales, Cabra, Monturque, Aguilar, and Puente Genil, and in 152,000 hectares of various other districts.

So that the topographical triangulations have been observed over an extent of 506,000 hectares, and the planimetry completed in 320,000 hectares of the province of Cordova.

The province of Madrid, in which for some years works of cadastral topography have been carried on, required primarily that the topographical triangulations of the districts, in which these have been completed, should be connected with the geodetic work of the third order; that the remaining survey should be projected and the observations made; that the completed sketches should be reduced, and those which are not should be drawn, in accordance with the new instructions; and that the levelling, when it is necessary, should be finished.

The result obtained in an interval of time equal to that in Cordova, by 16 officers and 10 topographers with their provincial chief, was the selection of 360 vertices for the triangulation, the occupation of 246 vertices with the theodolite, and of 5,281 stations with the compass, the measurement of 1,070 kilometers, the making of 9,696 levelling-stations, and the fixing of 59 boundary-lines. The rest of the force has been occupied in office-work, finishing those works which were incomplete, and making the necessary reductions.

In the latter part of March, to commence the operations in the province of Seville, six parties set out, formed in the same manner as the Cordova

parties, and also under the orders of an officer of the Corps of Topographical Engineers, in charge of the topographical surveys of the province.

By special command of the government, the cadastral topographical works, which are about completed, have been continued in the districts of Cartagene and Valdeolivas, in the provinces of Murcia and Cuenca. The municipalities have borne all the expenses except the salaries of the assistants.

PUBLICATION OF THE MAP.

The topographical and geodetic works of the first order having been united in one establishment and placed under the same direction, the azimuth of one side of the triangulation having been determined, orders having been given for making the levellings of precision which are to do away with the uncertainty regarding the altitude of Madrid, a force having been organized among the officers of the Corps of Topographical Engineers competent to develop in convenient proportion the triangulation of the second and third orders; this corps, composed of 300 individuals, having devoted itself to the topographical operations which the construction of the general map of the territory requires, and lastly, the results previously obtained, with other ends in view, having been utilized, after being completed, it has been possible to plan the preliminary arrangements for the publication which all the nations of Europe, including Portugal, have at least commenced many years ago.

The general directions, which, in accordance with the proposition of the Geographical Institute, His Highness the Regent of the Kingdom has been pleased to dictate, under date of the 30th of September, 1870, are: 1st, that the publication shall be made on a scale of 1-50,000; 2d, that the map shall be divided into sheets of 20 minutes' base in the direction of the parallels by 10 minutes' altitude in the direction of the meridians; 3d, that the portion of the terrestrial surface represented on each one of the sheets shall be considered as a plane, without subjecting the map to any system of general projection.

So much for the publication on a large scale; but as this class of works is not, on account of its cost, within the reach of the public, it is necessary to study the conditions which should govern the publication of a reduced map.

In the first place is presented the question of the system which it may be convenient to employ for the projection of this reduced map, and concerning this, careful studies are being made by the chief engineer of roads, canals, and ports, who is charged with the publication of the map by the Geographical Institute. He is also occupied in examining the different systems of representation and material methods of reproduction, in order to propose those which it may be convenient to adopt in our country.

This section has devoted itself, moreover, to all the labors of the commission for the territorial division of Spain for projecting the provisional law upon the organization of the judicial power—a commission appointed by the minister of grace and justice, and to which the director of the Geographical Institute and the chief engineer of the section, who discharges the duties of secretary, belong as voting members.

ACCOUNTABILITY.

This section, composed of a chief, an assistant officer, and four clerks belonging to the civil administration, has been occupied from its creation with all the measures pertaining to an economical administration. It

formed the project of instructions in force for the service of accountability of the Geographical Institute; has examined the accounts which are rendered monthly from the field by both the geodetic and topographical parties, whose total number now reaches more than 30; has made payments of bills; has assisted, as opportunity offered, all the business of the depositary of funds; has issued instruction for the necessary expenditures, and has given information to the other sections in regard to services by which expense is incurred; and, finally, it fixes the rates of pay and allowances of all the personnel. It has also had charge of the registry of letters sent and received, and of the service of the (cierre?)

Translated from "*Descripcion Geodesica de las Islas Baleares*," by Lieut. P. M. Price, Corps of Engineers.

CHAPTER VII.

§ 1. Notes on the Topographical Survey of Switzerland.

GENERAL PLAN OF THE SURVEY AND PUBLICATION.

The Dufour chart of Switzerland is on a scale of 1 : 100000.

On the 18th of December, 1868, the Confederation resolved to have original topographical sheets made for those Cantons where no such sheets existed.

The cost was to be equally divided between the Swiss Confederation and the Cantons.

SCALES EMPLOYED.

The scale of the original topographical sheets, which are all $0^m.35$ long by $0^m.24$ high, is 1 : 50000 in the vicinity of the Alps and 1 : 25000 elsewhere.

A sheet on the 1 : 50000 scale represents a distance of $17{,}500^m$ from west to east, and $12{,}000^m$ from north to south, and contains 9.11 square stunden, (1 stunde = 4,800 meters.)

A sheet on the 1 : 25000 scale represents a distance of $8{,}750^m$ from west to east, and $6{,}000^m$ from south to north, and contains 2.28 square stunden.

The border gives the longitude and latitude after the modified Flamsteed's projection.

The sheets are also divided into rectangles of $1{,}500^m$ or $3{,}000^m$ distance from the meridian and its perpendicular at Berne.

The rectangular co-ordinates are computed from the projected geographical co-ordinates.

The published sheets are on the same scale and are scarcely changed copies of the original sheets.

The sheets on the 1 : 25000 scale are engraved on copper; those on the 1 : 50000 scale, on stone.

MATERIALS AVAILABLE.

The topographical sheets made either under General Dufour or by the Cantons subsequent to 1837, were available for the new survey. Many of these were on a scale of 1 . 100000 and without level curves.

This portion has to be done over, and all the old sheets are to be revised and corrected.

LEVEL CURVES.

The topographical work is based on triangulations of the first, second, and third orders.

The level curves are 30^m apart for the 1 : 50000 scale; 10^m for the 1 : 25000 and in exceptional cases 8^m and 4^m. Each tenth curve is broken and its height written upon it.

INSTRUMENTS.

For the 1 : 25000 scale the plane-table with vertical circle compass and stadia is used; and in the high mountain region, where the scale is 1 : 50000, a smaller plane-table without stadia is used.

ORGANIZATION OF THE SURVEY.

The survey is under the immediate charge of the chief of the staff bureau of the Swiss army—at the present time, Colonel Siegfried—and constitutes the topographical division of the bureau.

The employés of the topographical division receive their orders direct from the chief of the staff bureau, and, as a rule, by monthly programmes of work.

At the end of every month every person charged with work is required to submit a report to the chief of the staff bureau on the execution of the orders received.

The personnél of the topographical division is as follows:

1. The engineers.
2. The topographers and draughtsmen of the office.
3. The engravers on copper, and the lithographers.
4. The printers.

The engineers comprise:

a. One verification engineer.
b. One triangulation engineer.
c. A number of engineers for the revision.
d. A number of engineers for new surveys.

As a rule, the engineers who execute new surveys are paid by the square stunden of work done, a special agreement being made for each section of work given out.

The other engineers either receive yearly salaries or are paid by the day.

On the 2d of May, 1873, the chief of the staff bureau, Colonel Siegfried, fixed the price of topography at 700 to 800 francs per square stunde on the 1:25000 scale, depending on the character of the work as shown by the revision in the field.

For the 1:50000 the prices are one-half of the above.

The co-ordinates of a sufficient number of trigonometrical points are furnished to the engineers who undertake to do the topography.

A portion of the engraving and printing of the sheets is done in the office by employés at a fixed salary, but the greater part of it is done by contract with private parties.

The following synopsis of the instructions issued for the execution of the work on the different scales will show the character and scope of the survey and of the final atlas:

INSTRUCTIONS FOR TOPOGRAPHICAL WORK ON THE 1:50000 SCALE, BY GENERAL DUFOUR.

Objects to be shown.—All streams, crests of mountains and summits of hills, all roads, lakes, ponds, marshes, mines, quarries, and peat-bogs; glaciers, masses of rock, moraines, ruptures of soil; woods and vineyards, whose contours must be accurate; cities, villages, and hamlets; isolated houses are less important; bridges, ferries, and fords; roads are to be represented by black lines; water by a blue tint; dwellings in red; woods by a pale yellowish green; vineyards by pale violet; marshes by blue and green panaché; stone bridges by a red, and wooden bridges by a black line; limits of cantons by a broken red line; peat-bogs by pale brown.

Writing must be in careful round hand. The leveling is to be as precise as the instrument admits; level-curves, 30^{m} apart, in burnt sienna. Beginning and end of slopes in dotted lines and intermediate curves, if

needed, in same way. Crests of hills, heights of streams, and other important points, being fixed by leveling, the curves will be generally traced by the eye. Their object is to fix the hachures to be added after. They will give the general forms, but all abrupt accidents of the surface must be represented directly by hachures.

INSTRUCTIONS FOR THE 1:25000 SCALE, BY COLONEL SIEGFRIED, MAY, 1868.

1. *Graphic triangulation.*—The topographer must first determine by rays from the trigonometrical points the positions and heights of a great number of other points on the plane-table.

After the triangulation points, he will occupy his well-determined points.

2. *Drawing of details and topography.*—In accessible ground this will be done by stadia lines, with compass-needle and plane-table, sighting to and from all main stations. All observations are to be recorded in note-book.

Objects to be drawn.—All those of the 1:50000 scale, all buildings, alleys, and considerable groups of trees. Limits of individual properties, and cultivations, are not required, as these would overload the map.

Hedges that would impede troops must be given.

The conventional signs are the same as for the 1:50000 scale.

The heights of all important points are to be determined with the utmost precision, using geodetic methods.

Less important points for fixing level-curves, of which many are wanted, may be determined by the quadrant of reduction.

Level-curves are to be 10^{m} apart, and drawn in burnt sienna; the limits of slopes, intermediate curves, when needed, and every tenth curve, being dotted.

The heights of level-curves are to be written in brown, and of leveled points in black.

The general forms are to be given by the level-curves; base rock, by black curves, or if steep, by black hachures; very steep and broken earth, by brown hachures.

Accuracy.—In verification the mean error of ten observations on clearly visible points from a trigonometrical station, shall not exceed 0.5^{mm}. Errors of 1.2^{mm} are not allowable.

The greatest difference in heights of leveled points when determined from three to five stations, must not exceed 5^{m}.

Elevations under 5° must habitually be used in levelling.

In projection of valleys and crests no level curve must be in error by its distance from the next; that is, no curve must be out by 10^{m} in height.

INSTRUCTIONS FOR THE REVISION OF THE SURVEY SHEETS BY COLONEL SIEGFRIED.

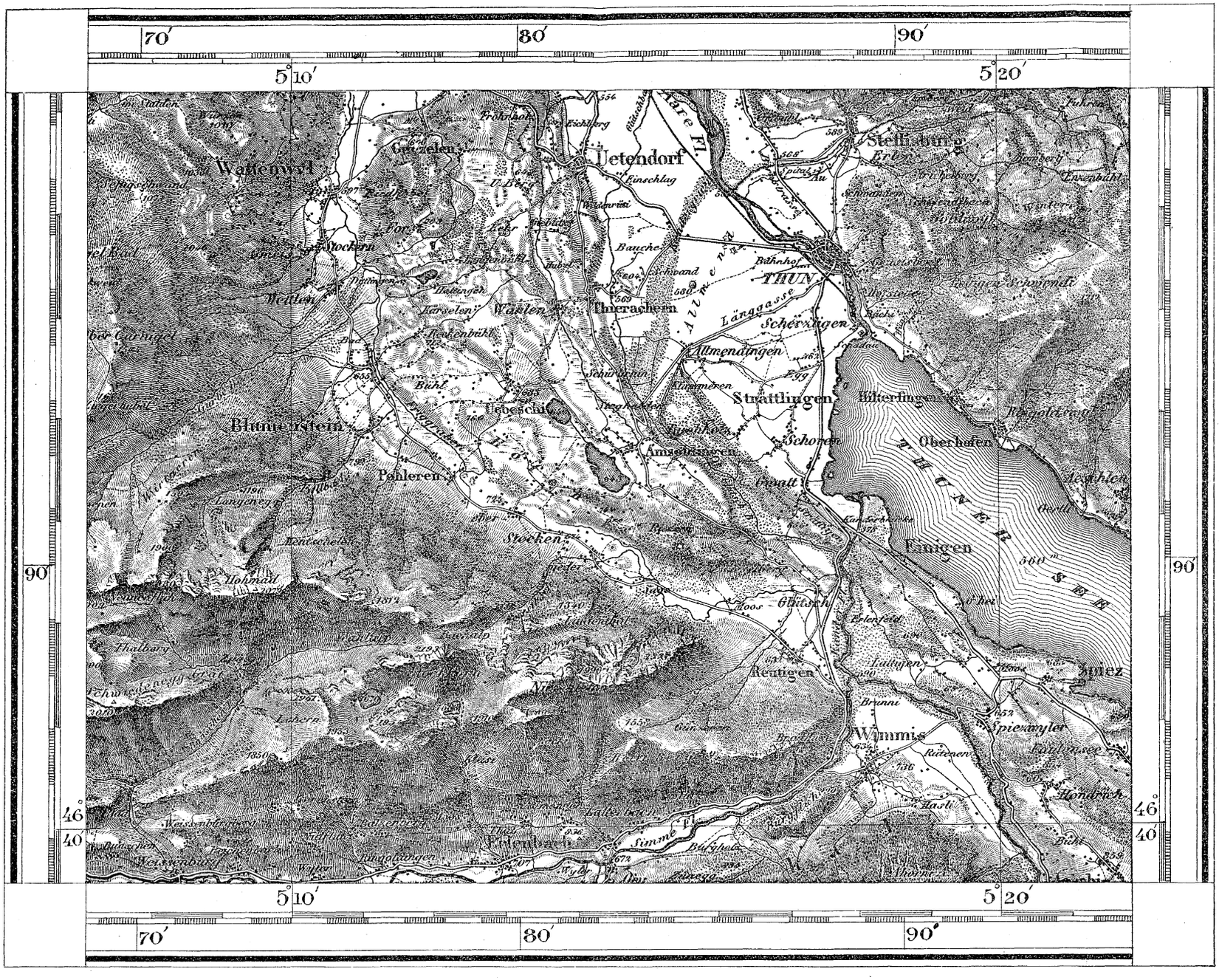
Triangulation.—The trigonometrical points must be permanently marked either by the setting of stones of fixed dimensions, or by cutting marks in the rocks.

Planimetry and hypsometry.—The chief of the staff bureau designates for each section the extent of the verification and revision.

The positions and heights of the points of the country are verified from the triangulation stations.

SWITZERLAND

Part of PLATE XII



Scale $\frac{1}{100000}$

Date 1860

All alterations and new constructions of roads, and all changes in the towns and settlements, must be surveyed.

The cantonal and district boundaries must be surveyed.

The boundaries of forests and townships must be carefully revised.

The hypsometry must be completed, so that altitudes shall be given at the points of confluence of rivers, at bridges, and at a sufficient number of intermediate points to show the slopes of the rivers; at all towns, at road-crossings, and at a sufficient number of intermediate points to show the grades; at the summit and passes of mountain ridges, in the valleys, and at prominent points throughout the territory.

Names.—The engineer will ascertain from intelligent inhabitants the correct names of places, rivers, roads, mountains, glaciers, &c., as well as the local methods of spelling such names. He must also obtain the popular names of parts of the terrain which form topographical districts, such as valleys, gorges, plains, plateaux, &c.

As results of the revision the following documents are required:

a. The verification record.

b. A drawing on the scale of the original containing the surveyed alterations and corrections, and the corrected and completed nomenclature.

c. The field-book for hypsometrical observations.

d. A record of altitudes according to form.

e. A list of names, with the different methods of spelling the same, and the authorities therefor.

f. A list of streets and roads, containing, in the columns from 3 to 3, the distances in marching time, the widths, greatest grades, and the classification of the roads.

RESULTS ACCOMPLISHED AT THE END OF THE YEAR 1874.

A general chart of Switzerland in four sheets, on a scale of 1:250000, has been completed and published.

The Topographical Atlas, when finished, will include 546 sheets on the 1:25000 and 1:50000 scale.

The survey and revision of 161 sheets has been completed. Of these 161 sheets, 75 have been published, 26 are in the hands of the engraver, and 60 are ready for the engraver.

The Dufour map of Switzerland, on a scale of 1:100000 was begun in 1837, and completed several years ago.

It is corrected for changes from time to time.

Authorities.—Instruction pour les levés au 50m., Général Dufour (1:50000). Für topographische Aufnahme im Maasstab 1:25000. Colonel Siegfried, 1868, Erläuterungen zum topographischen Atlas der Schweiz. Organisation des Stabs-Bureau: Topographische Abtheilung, by Colonel Siegfried, 1875.

Arranged by Lieut. P. M. Price, Corps of Engineers.

CHAPTER VIII.

§ 1.—Memoir on Swedish surveys, by Col. Victor von Vegesack, Chief of the Topographical Division.

Topographical Division of the
General Staff, No. 131,
Stockholm, November 16, 1875.

STATISTICS RELATING TO THE GEODETIC AND TOPOGRAPHICAL WORKS EXECUTED AND IN PROGRESS IN SWEDEN, THEIR EXTENSION, PRESENT CONDITION, COST, ETC.

ORGANIZATION.

Before topographical surveys, map-making, and description of the country were intrusted to a special corps organized for that purpose, such work was attended to by other officials or by private parties.

When the Swedish land-survey was established, in 1603, its main object was work of a geographical character, surveys of private property being only secondary. Bureus, the first chief of the land-survey, published, as early as 1626, a condensed map of the whole kingdom, and afterward maps of Svea-land,[1*] Gotha-land, and Finland, and of several Swedish and Finnish provinces.

During the next forty years the work on larger maps came to a close, but was revived by King Charles XI, who, in 1683, issued instructions for the land-survey.

The land-survey received a first change in its course of action through the ordinance concerning *skiftena*, (the shares,) or the division of the village communities into independent lots. This change was made in 1743. In 1765 the geographical work had to give way entirely to the "shares," and was not attended to again until seventy years afterward, and then but slightly. During this interval, Baron S. G. Hermelin, a Swedish geographer of high merit, made explorations in Westerbotten and Lappmarken, and published maps of Norrland and Finland.

The government[2] granted him the privilege of publishing for a period of fifteen years provincial maps of Sweden, in accordance with an adopted plan. For the central and southern provinces "hemman maps" were compiled, and ever since 1798 there had been in progress astronomical determinations of geographical positions, the need of which had by this time become sensibly felt. During ten years sixteen maps were published by Baron Hermelin. In 1809 his lack of means threatened to stop the map-work, and it was offered to the government for redemption, but the Assembly of the Diet refused to appropriate the necessary funds. Two private individuals, the Barons Bonde and Adelswärd, then came forward, with whom Hermelin agreed to form a stock company, assuming the name of "Geografiska Turättningen," (the geographical institution,) and five of the maps bear the name of this firm. There are altogether thirty-one maps in the Hermelin collection, of which twenty-two were constructed by C. P. Hällström. The proposition made in 1809 to transfer the map-establishment to the government was again brought forward in the Diet of 1823. The assembly this time gave its consent, and the map-work was transferred to the previously-organized land-survey office. No new maps were published while it was in charge of this office.

The charts were compiled exclusively from the land-survey operations,

* See note at the end.

and consequently those of Hermelin are insufficient for military use, being published on small scales, not showing the relief of the ground, or the timber, and the swampy land only in part. The need of maps with good topography, felt during the many wars in Europe since 1792, gave in most countries the first impetus toward the formation of extensive connected topographical atlases, which were afterward and are still executed by military corps organized for that special purpose.

Rather comprehensive Swedish military maps were in course of preparation as early as the beginning of 1770, in the neighboring country of Finland, under the direction of Major-General Sprengporten and Colonel Klercker. There are in existence also earlier Pomeranian and Norwegian boundary maps prepared by the Royal Fortification Corps, which are a credit to those who executed them. An entirely new epoch in Swedish topographical operations was introduced in 1805, when, at the suggestion of Maj. Gen. G. W. af Tibell, the Swedish Field Survey Corps was established. By the royal letter of April 16, 1805, and instructions of 1806, the object of this corps was declared to be to compile in time of peace complete military maps of the kingdom based on trigonometrical and astronomical observations, accompanied by topographical, statistical, and military descriptions. Necessary instructions for the execution of this work were given, among which were, that the scale for the field-work and the preliminary map should be 1 : 20000, and for the so-called special maps which were to be compiled from them 1:100000, and that the corps in time of war, in co-operation with the general staff of the army, should perform such duties as in most countries belong to the staff of a quartermaster-general. In conformity with this, by royal order of 1806, the title of "quartermaster-general," which subsequently has been applied to the chief of the fortification corps, was conferred on the chief of the field-survey corps. The balance of the force consisted of one lieutenant-general quartermaster, one major, one professor, four captains, (of whom two were adjutants,) six first lieutenants, six second lieutenants, one clerk, and two draughtsmen. To the corps was joined a bureau called "archives of war," where all government collections of domestic and foreign military maps, &c., formerly scattered in various places, were deposited, and funds were appropriated to increase the collections of the archives by yearly purchases of maps, books, and instruments.

At the time of the Diet of 1809 the idea seems to have gained ground that the field-survey had been wrongly separated from the fortification corps and ought to be reunited with it, economy being held forth as the motive for this union. The result was not entirely satisfactory. The government declared in 1811 that both corps should be placed under one common chief, to which position, by general order of July 3, of the same year, Maj. Gen. af Tibell was appointed. Shortly afterward it was ordered by the government that the corps thus united should bear the name of "The Royal Engineer Corps," but remain divided into two "brigades," the fortification and the field-survey brigade, each of which maintaining its order of promotion, should continue with the same duties which had hitherto been prescribed for it. The saving was slight and the union loose. It continued for twenty years.

Doubts as to the practicability of the union with the fortification-corps were expressed officially in 1814, principally on account of the duties which in the field fell on the field-survey brigade. Explorations, projects for trails, camps, positions, quarters, defenses, and the like, which in time of war belong to officers of the field-survey, have the most intimate connection with the services of the general staff, for which

reason the brigade ought *then* to be in co-operation with the staff, and only in time of peace be separated from it. It was not until 1830, however, that in Sweden the question of the separation of the two brigades was brought up in earnest. This course was advised mainly by the then chief of the engineer corps; after which, in 1831, the government ordered that the field survey brigade should be separated from the engineer corps, and, under the name of the topographical corps, should form a special division of the general staff placed under the command of the adjutant-general of the army in all concerning the inspection of the corps and the general arrangement of the work. The new chief, the then brigade chief, Colonel Akrell, took charge and continued for a quarter of a century to devote his active care to the art of topography. In 1856 he resigned, and was succeeded by Col. J. A. Hazelius.

By a royal order issued in 1831, the topographical corps was completely organized. The force was to consist of one colonel and chief, one major, one professor, three captains, six lieutenants, one draughtsman, and one messenger.

Since January 1, 1874, the topographical corps has been dissolved and united with the re-organized general staff. The topographical work is now executed by the "topographical division of the general staff."

FORCE EMPLOYED AT THE MAP ESTABLISHMENT.

Some officers of the army had already served from 1805 to 1815 in the field-survey corps. To hasten the surveys, it was directed in 1821 that officers with some skill in map-drawing should be ordered from the army every year as assistants in the summer-work of the field-survey brigade. If this assistance was required at that time, it was still more called for when, through the organization of 1831, the strength of the corps from 21 persons, to which it had shortly before amounted, gradually decreased to 11 officers of the regular service.

In 1834, a rule was established that to fill the places of second lieutenants withdrawn, a number of army officers sufficient for the work at the time should be detailed, and together with the topographical officers and under the command of the latter, should make field-surveys and work pertaining thereto; these officers being required to have as much skill in field-surveying and map-drawing as is demanded of the cadets at graduation. In this way, the map-work was hastened and the army officers gained experience in surveying. But most of the officers detailed served altogether too short a time to benefit the map-work in proportion to the expense. Experience has proved that two or more summers, according to different natural talent, are required for gaining sufficient skill in complete field-surveying; and as according to custom only one-third continues the third summer, when the principal gain for the map-work would begin, in 1847 it was ordered that there should be employed for continuous service, for a term of three years, six or at most eight officers who had previously served in the corps at least one year. The number of applicants was never equal to the demand. To supply the deficiency and to have a permanent working force at command, the royal majesty[2] permitted in 1858, at the request of the chief, the employment in the corps of eight sub-officers (*guider*) who were to devote themselves exclusively to map-drawing, in order to attain the technical skill desired. At the end of 1873, shortly before the topographical corps was entirely united with the general staff, these sub officers were relieved, but those wishing to continue to devote their

time to map-drawing were retained under the name of extra assistants Three of these who had for some years been engaged in map-engraving were employed as engravers.

To show how large a force is generally engaged in the topographical work, it may be mentioned that in the summer of 1875, 28 persons took part, among whom were 8 officers, a professor, and two aspirants, belonging to the general staff, 12 officers of the army, and 5 civil assistants. This year 24 persons were engaged on the winter work, of whom 10 belong to the general staff, 5 are civil assistants, and 9 are officers detailed from the army. The number of engravers is at present 7.

THE PROJECTION OF THE MAP.

The method of projection adopted for the Swedish atlas was worked out in 1816 by Second Lieut. Count C. G. Spens. It was regarded as important, for a comprehensive military map for field use, that as large a territory as can at once be surveyed by the eye should take, without noticeable error, a conformable shape on the paper. Count Spens calls this quality "correctness of contour." It exists in two older projections, "the stereographic" and the "increasing cylindrical," but as the simplicity of the projection net was regarded as being of particular importance, satisfaction could not be obtained from the former, in which, when the compression is considered, meridians and parallels are indicated by ellipses or by circles. The increasing cylindrical projection, again, causes such a considerable change in the scale that it is seldom used, except when one is to be guided by compass, as for lake charts. Its chief property, that the scale increases from the middle toward north and south, was by Spens applied to the conical class, and he thus became the inventor of a new method, which he called "the increasing conical projection." The projection error in the increasing conical method, as in the stereographic, consists in the changeableness of the scale. It is so arranged that the error becomes equal at both borders of the map in north and south, and in the direction at right angles, somewhere in the middle. The projection belongs, consequently, to that part of the conical class called "intersecting," and is such that the projected surface, to its minutest parts, conforms to the one to be represented. The scale is a little too small at the middle of the map, at the north and south borders a little too large, and at the two latitudes correct.

In the documents of the Royal Scientific Academy for 1817, the inventor has given a complete investigation of the formulæ pertaining to this method. From these it will be found that the inner maximum of the error does not strike midway between the limits, neither do the correct parallels come half-way between the center and the borders, as is still usually assumed.

The whole calculation extends from the borders of the map. For these borders were selected the most southerly cape of the province of Schonen and the most northerly bay of Botany Bay. No map on a large scale seemed to be required north of this bay, and even if the map was to be extended over Lapland and Finnmarken, it was thought better to place a greater error in those out-of-the-way places, so as to have the more southerly and more thickly inhabited territories better represented. The meridians are indicated by straight lines and the parallel circles by concentric circles. The cone by whose development the map is obtained intersects the spheroidal globe along two parallels, 56° 57′ 31.5″ and 64° 22′ 59.5″, at which points the error of

the projection is zero. The greatest projection-error amounts to 0.0021, and occurs at the adopted boundary latitudes in north and south (*i. e.*, 65° 50′ 20.4″ and 55° 21′ 19.4″) and at the degree of latitude which is equal to half of the conical angle, or to 60° 44′ 29.6″.

The compression of the globe is in the Swedish projection net assumed $= \frac{1}{304.2607}$ and the radius at the equator = 6376797.06 meters, which figures were at that time looked upon as being the most probable. To approximate these after every new observation has been regarded as leading to confusion rather than to advantage, and consequently they have been retained in the calculation of the triangulation net.

For the principal meridian that is adopted which runs 5° west of Stockholm Observatory, and which is also very nearly the same as the central meridian of the Scandinavian peninsula.

DIVISION INTO SHEETS.

In accordance with the plan adopted by the government for the Scandinavian map-work of 1816, it was determined that for the Swedish military-map work the sheets should be of a rectangular form 594^{mm} long and 445^{mm} wide. The principal meridian makes one side border on all sheets where it is to appear; the other sheets have two sides parallel to it, and two at right angles. The sheets are numbered with Roman numbers sideways in both directions from the principal meridian, while their position east or west of this line is indicated by Ö (for Öster = east) or V (for Vester = west.)

In the north and south directions the sheets are numbered with Arabic figures, counting from the perpendicular to the principal meridian at the nearest full degree north of the peninsula, or 72°. Thus, for example, Stockholm on the sheet is V Ö 32. Each sheet is named after some city or other place of note within its boundaries.

The whole atlas comprises 232 sheets, if Lapland is included. The area of the whole kingdom, however, corresponds to only 169 full sheets. Each sheet contains 2,644.55 square kilometers. The area of the whole country, including the larger lakes, is very nearly 8,046 Swedish geographical square miles.

TRIANGULATION.

The oldest Swedish triangulation net known was laid out by N. Schenmark in 1758 to 1761, from Cimbrishamn, in Schoonen, along the coast to the boundary of Norway. The net is narrow in some places, and the defective instruments which were then used and a want of care in the reduction of the angles prevent its acceptance as reliable. It is, however, the only case in olden time in Sweden where an idea of triangulation on a large scale has been carried out. During the forty years following various coast-triangulations were executed for the compilation of lake charts separately for each locality, and often with very little connection. Some of these surveys are regarded as unreliable; concerning others only incomplete information remains.

The first attempt of the field-survey corps in this direction in 1807 between Stockholm and Upsal led to no other result than giving the officers practice in field-work. In the same year a triangulation was made of the city of Stockholm.

In 1812, triangulation-nets were laid out along the whole coast of Schoonen. The measured base was 6,207.421 meters. The nets were based on Lund Observatory. The number of signal-stations was 52, of which two were in Denmark. No intermediate stations were fixed, and

the positions of the signal-stations were not designated by permanent marks, for which reason the net was of use only during that survey. A new net through the same province, but which extended farther into the country, had therefore to be laid out 26 years later. The point of reference for the whole Swedish triangulation net is the Observatory of Stockholm, beside which the Observatory of Lund had been connected by a special survey conducted by the Royal Scientific Academy with the main triangulation of the topographical corps. As a check on the work, latitudes were observed at several of the triangulation-stations. The position of the net is fixed by the determination of the azimuth of one of the sides of a triangle extending from Stockholm Observatory. Azimuth observations were also made at several other points for the sake of checking.

Besides the base-line in Schoonen, mentioned above, four others were measured—the first in 1815, on the southwest coast, near the city of Laholm; the second base was chosen on Lake Wœnar; the third on Lake Wetter. Both of these were measured in 1820. The fourth was located in the archipelago of Stockholm, across the bay of Mysingen. It was not until 1827 that the winter was cold enough to admit of its measurement. These four, besides the one in Schoonen, are measured with an apparatus of wooden rods, and consequently cannot be regarded as quite reliable. The lengths of these bases are: Laholm, 13,314.132 meters; Wœnar, 15,135.763 meters; Wetter, 16,816.109 meters; Mysingen, 14,300.609 meters.

New measurements of base-lines have since been undertaken, six of which may claim to satisfy all the requirements of the present time as to accuracy. Among these was one measured in 1839 and 1840, in Oeland, by the Topographical Corps, with the base-measuring apparatus which was used by Bessel in East Prussia in his measurement of an arc of the meridian. For the site of this base-line the elevated limestone plateau which, under the name of Alvaren, runs along the island Oeland was selected. The base was measured twice, in accordance with the present custom.

The first measurement, in 1839, gave, according to one observer's reading, 5,473.071 meters; according to the other observer's reading, 5,473.084 meters; mean, 5,473.0775. The second measurement, in 1840, gave, according to one observer's reading, 5,473.082 meters; according to the other observer's reading, 5,473.092 meters; mean, 5,473.0880. The mean of the measurements of the two years is consequently=5,473.0877 meters.

The extremities of the base-line were marked by two stone pillars, cut smooth at the top, with masonry foundation, and over which arches were built.

In 1863 three base-lines were measured for the Central European measurement of degrees, under the superintendence of the Swedish Scientific Academy, with an entirely new base-apparatus, made by Berg, of Stockholm. This base-apparatus is, in the main, similar to the one constructed by Struve, but with some important alterations, made by Major-General Wrede, which considerably simplify its use.

As something remarkable, may be mentioned that in the measurement of one of the bases, during a full day, as many as 270 rods were laid out; and to show with what accuracy one can measure with this apparatus, may be stated that in one of the bases which was measured twice the discrepancy amounted to only 0.0029 meters.

The base-lines are, one on Ladugards gärde, near Stockholm, 2,295.045 meters long, connected with the triangle side Lökenäs-Trindtorp by a

triangulation net comprising 13 stations. The second base was measured on the sandy plain at the mouth of Laga River, in Halland, 6,923.732 meters long, connected with the triangle side Wilse-Härad-Knösen by a system of six stations. The third base, measured on Axevalla heath, in West Gothland, is 2,618.667 meters long, and connected with the sides in the main triangle Skära-Kinnekulle-Billingen by a net comprising 10 triangulation-stations.

Two base-lines were measured by the topographical corps in 1870 and 1873, at Fahlun and at Umeå, with the above-mentioned apparatus, which was borrowed from the scientific academy. The former of these bases has a length of 4,099.600 meters, and for the latter, which was measured twice, were obtained the lengths 3,189.0452 and 3,189.0479, or, when the mean of the results is taken, 3,189.0465 meters.

The forest of Swedmoften prevents the determining beforehand of where the main lines of the net should run. The features of the country and the need of economizing have necessitated a preliminary examination to find where it may be possible to carry through the triangulation net. Hardest to pass are the limits between the provinces, where the ground is generally rough. Next in difficulty are the mining and manufacturing districts. Easiest is the archipelago, next are the territories where an originally Finnish population has, through persistent clearing of the land, prepared an open view.

The length of the sides, consequently, had to depend on circumstances, and cannot be even approximately stated. There are some which are hardly 5,344 meters. One (Omberg-Taberg) is 77,391.161 meters. Forty thousand meters is regarded as inconvenient, and 20,000 meters is the best. Signals have usually consisted of pyramids, covered with boards nailed on at short intervals, and with a black barrel or a white target on top. The points where the signals have stood are designated by durable marks, either iron plugs inserted and secured in the mountain or by marks cut in the rock.

The location of the net and the building of the signals are attended to by the officers. Angle observations are made partly by professors and partly by the officers of the Topographical Corps or of the general staff. The professor is accompanied in this work by an officer to assist and to learn.

Three larger and six smaller theodolites were used in the survey. The oldest was made by Reichenbach and Liebherr, and has diameter of limb = 0.4314 meters. One with diameter of limb = 0.32026 meters was received, in 1834, from Littmann, of Stockholm. Each has 4 verniers, which read to 4 seconds and may be estimated to 2 seconds.

Since 1871, an excellent universal instrument, made by Repsold, of Hamburg, has been used in the primary triangulation. It is constructed with a broken tube, and has horizontal and vertical circles of 12 and 10 Parisian inches respectively. In reading, microscopes are used. The instrument has given results which, as regards accuracy, leave nothing to be desired.

In some places astronomical locations were resorted to, but have proved unsatisfactory, on account of their unreliability. An attempt was then made to ascertain whether small triangles could be carried through where large ones were unattainable. This caused the use of smaller theodolites, suitable for triangulation-lines of the second order, extending from the main system. Observation and calculation occupy here about the same time for the same distance in miles. The principal advantage of the smaller instruments is that they can be more easily

transported to and from the stations. Three were made by Littmann, of Stockholm, and three by Jünger, of Copenhagen.

At the present time a triangulation net of the first order stretches along the entire coast of Sweden from Svinesund to Torneå. Besides this, and in conncetion with it, systems of triangulation have been laid out with the same accuracy in the direction of meridians and parallels. Triangulations of the second and lower orders within the lines of the main system have in these parts of the country within a short period given points sufficient in number for the atlas. Northern Sweden has as yet few geographical positions, but, as the final triangulation of the southern and central parts of the country is soon to be completed, the geodetic work in that part of the country can be carried on with more energy.

LEVELING OPERATIONS.

In former times no particular importance was anywhere attached to the rise and fall of the ground. In this country it was necessary not to divide among too many works the small appropriations and the limited force which could be employed on the map-work. When noticed, however, that Sweden stood alone in this, the observation of altitudes began to be attended to at first only as secondary work, in connection with astronomical observations and triangulation. But little time was given for this purpose, nor could suitable locations always be obtained; for if the point is not situated either on a water-course or on a water-shed, the knowledge of its elevation is of little value. During the last two decenniums a complete examination of the ground features has been made, partly by the topographical corps and partly by the office in charge of the Swedish geological survey. The works of the different offices are performed on a common plan and in connection with one another.

The examinations are made by leveling, and start from the mean water-level of the Cattegat and the East Sea, (Baltic,) which has been obtained from observations on the water-heights made at the light-houses during many years in succession. Lines of levels are run across the country from sea to sea. The east and west lines are combined with lines running north and south. From these main or check lines extend detail-lines, through which points sufficient in number are determined for the requirements of the map; 30 to 40 points are generally included within 114 square kilometers. (See further the method of working on the scale of 1:50000.)

During late years trigonometrical leveling has been connected with all triangulations.

SKELETON MAPS.

In Sweden, for more than twenty years, a bureau has existed called "Central Archives," the general land-survey office, where copies of all geometrical maps are preserved; and in the provinces a special department, called "Provincial Archives," for the original maps. These maps, through their number and the large scale (1:4000) on which they are usually constructed, give an opportunity for simplification which has not been neglected in the military map-making of the country. Thus, with the aid of the means just referred to, a so-called skeleton map has been compiled since 1828. The skeleton map is put together in the following manner: Those geometrical maps retained in the land-survey archives which are not from age or from other reasons regarded as useless are reduced to the scale adopted for the field-survey. When land-survey maps could not be obtained, the interval has been filled either by

distance-measurements, or, when the triangulation-net was distant, a base-line was measured on the ice the previous winter and a smaller triangulation-net extended from it; occasionally the complete survey by land-surveyors on the ice of one or more lakes or morasses has been provided for. After these preparations, when a number of larger or smaller map-pieces has been collected, they are put together to form a whole. This putting together is carried out in the following manner: On a large table, with a perfectly plane top, all the triangulation-points, spherical as well as plane, are plotted according to scale. These points are located during the triangulation proper with reference to surrounding objects, so that they can be plotted each on its respective piece. Each such piece is now laid over the corresponding triangulation-points on the table and is attached thereto with a needle, which is pricked through the point on the paper. Next are arranged round these all the remaining pieces in their proper positions, which can be ascertained from the inscriptions round the borders of each piece. All that now remains is to move and fit these numerous pieces so that they become one harmonious whole, taking special care that those pieces on which the triangulation-points are remain perfectly undisturbed. Small errors exist throughout the whole, partly from the shrinking of the paper, partly from possible mistakes in the survey, and these errors must be so distributed over the whole surface that the unavoidable overlappings and intervals become the smallest possible. This requires continual fitting and adjusting; a work which demands considerable experience, accuracy, and skill.

When at last all the pieces have been made to fit, they are glued together, the sides are drawn at right angles, and the sheets are cut apart and frames glued to them. The skeleton-map is then ready, and contains, or should contain, all the outlines of the territory to be surveyed. It is then divided into working-sheets of suitable size, and each sheet is transferred to tracing-paper, from which the sketching, by means of tinted paper, is again printed on the paper on which the survey is to be made.

Such has, up to the present time, been the method of constructing the skeleton-map. A different method will hereafter be adopted, since the government economy map-establishment has been, since 1873, placed under the command of the chief of the topographical division of the general staff. This map-establishment is preparing, with the aid of the locations of the topographical division, and with the same projection method, a plane-map of the central and southern parts of the kingdom on the scale 1:20,000. In those parts of the country where the works of the economy map-establishment precede the military survey on the scale 1:50,000, the economy map will be reduced to said scale and the field-survey made on a copy of the same. (See further on in "the working method" on the scale of 1:50,000, and those works executed by the economy map-establishment in the survey of the skeleton-map on the scale 1:20,000.)

METHODS OF WORKING IN THE DIFFERENT SCALES.

In Sweden the following scales are used for different purposes: 1:1,000,000 for the general staff; 1:200,000 for the "Län" maps[5]; 1:100,000 for the special map; 1:50,000 for the field-work of the special map, or the so-called concept-map; 1:20,000 for pass and position maps; 1:10,000 for more important passes and positions. For special purposes, surveys on still larger scales have been made, as 1:5,000 and 1:1,000.

The work in the field for the military map was at first executed on

the scale 1 : 100,000, on which scale maps were made of the whole coast and of a great part of Central Sweden, or the whole territory around and between the large lakes Wenner, Wetter, Hjelmar, and Mœlar, in all an area of about 160,000 square kilometers. During this work, the difficulty of producing a sufficiently accurate and complete map of a land like Sweden, with subdivisions into such small tracts, and with the field-sketching not made on a larger scale, was fully recognized. For this reason the scale for the field-survey was changed in 1844 to 1 : 50,000, which has ever since been used for this purpose, and on this scale maps have been constructed of an area of about 65,000 square kilometers in the southern part of the country.

The field-survey, for which the surveyors are divided into parties of 8 to 10 officers, under the orders of a general-staff officer, is executed with all the accuracy that the scale will admit of.

On the scales 1 : 1,000 and 1 : 10,000 the smaller territories only are surveyed as cities, forts, and intrenchments, with their immediate surroundings, especially important passes and positions.

If the territory to be delineated is large, so much so that its outline cannot be included on one working-sheet, (or plane-table,) then it may be expedient to begin the work with plane-triangulation, which, if special accuracy is required, is done with a theodolite. Skeleton-maps are never used for those scales, because the errors would, with a comparatively slight reduction of possibly existing detail-maps on larger scales, be altogether too distinct and damaging in proportion to the accuracy demanded. For the larger scales, 1 : 1,000, 1 : 5,000, as a general thing, no detail-maps large enough are to be found which can be used for this purpose.

All objects, natural and artificial, are sketched according to their real size and shape, and hence the map is a complete horizontal projection. Lines of communication of all kinds generally form exceptions to this. The relief of the ground in the territory is designated only by the projections of equidistant horizontal contour-lines. The altitudes are reckoned from the lowest point of the territory. The plane-survey and the contour-sketching are made separately. For sighting, the index-ruler is used. Distances are measured by chain, fathom-rod, or stadia, but never by stepping. All elevations are taken with the level, and only exceptionally, in dense woods or in otherwise unimportant places, with the level-mirror.

The scale 1 : 20,000.—This scale is in Sweden used principally for surveys of passes and battle-positions, (and is therefore commonly called the "position-scale,") or smaller parts of the country which for some reason or other may be of particular importance. On this scale also such works are drawn on the skeleton-map as are compiled for the use of the special map. The skeleton-map can also be advantageously used on this scale if good land-surveyors' maps can be obtained.

Spherical and plane triangulations are made in the usual order, depending on the size of the territory. Such work is of course always done on those economy maps which are prepared on this scale, and serve as a basis for the topographical works. Artificial objects are, as far as the scale admits of, plotted to their real size and shape. Standard model-sketches show in what cases exceptions are permitted. The relief of the ground is generally represented by hachure-lines, which are sketched simultaneously with the plane-survey. Equidistant curves may also be used for this purpose; in which case, however, the plane-survey ought to have preceded.

The hachure-lines (the shortest slope-lines of the ground) are alto-

gether sketched by eye, and thus the "gradienter" gives the slope-angles and the leveling-mirror informs of doubtful relative heights. The features of the ground are next ascertained with the level, after which the map is finally redrawn. The result of the leveling is thus regarded as decisive, and at the same time this manner of proceeding effects a great saving of time, as the plane-survey and the relief-sketching can be done together. Besides, the best plan of leveling can be adopted, so that all necessary altitudes can be obtained in the easiest way. This could not otherwise possibly be done without the very roundabout way, which is, however, in principle the most correct, of first making a plane-survey of the ground, then working out the elevations, and finally sketching in the relief by eye. The projections of the horizontal section-lines, if this expression may be used, are obtained by means of horizontal sights with the level and leveling-mirror, as has been described above.

The setting up of the plane-table (orientation) should, wherever possible, be done by sighting to known points. Horizontal angles are measured by the common index-ruler. Distances are measured by fathom-rod or stepping.

The scale 1 : 50,000 is the preliminary scale for the special map which is prepared by the topographical division of the general staff on the following basis: The results of the geographical locations made by the topographical division of the general staff are delivered to a special skeleton-map establishment (Sweden's economy map-establishment) where they are used as bases for the economy map of the whole country, on the scale of 1 : 20,000, which is prepared by that establishment. This map, which contains all the outlines, or the total result of the plane-survey, is reduced to the scale 1 : 50,000 by the pantograph, after which it is put together in rectangular sheets 594^{mm} in length, and 445^{mm} in width, four of which will thus make one whole sheet of the topographical atlas on the scale 1 : 100,000. Every such skeleton-map sheet is divided either by parish-limits, or by straight lines into sections of optional size and form, but calculated to furnish work in the field for two or three weeks. These working-sheets are copied one by one on tracing-paper, after which they are, by means of tinted paper, transferred to vellum paper of the size decided on for the working-sheets. Skeleton-maps are also occasionally compiled by the topographical division in the manner previously described.

On these working-sheets the field-work is done with the plane-table, (a compass being fitted into the board,) index-ruler, and stepping. The orientation is done by compass. Hills are represented by hachure-lines, and mountains by horizontal section-lines. Slope angles are estimated by eye or by the aid of a slope-measurer, after which the drawing is finished with pencil.

During the progress of reconnaissance, data are collected for the description which every field-surveyor has to attach to his map. He carries for this purpose a note-book containing the columns marked in which the data are to be inserted, and the questions he has both to ask and to answer. This description contains all such strictly topographical and military information as the map cannot give, chiefly concerning the passability of the ground, or its adaptability for the movements of troops, consequently the slopes of hills or mountains, the accessibility of valleys, the depth of marshes, density of woods, crossing of water-courses, strength of bridges, condition of communication, routes, &c., all according to fixed instructions. To the description belongs also a name- and dwelling-list, giving an account of all inhabited localities

existing within the territory, industrial enterprises, &c. The chief of a field-survey division collects all these descriptions and condenses them to parish and provincial descriptions, which are afterwards deposited in the war archives.

The drawing in ink of the concept map progresses with the work in the field. When all the working-sheets are thus completed they are put together, the different field-surveyors paying particular attention to each other's limits to secure a perfect fit.

Lakes and all large streams are tinted light blue before the working-sheets are delivered. After the concept sheet is put together, all wagon-roads, homesteads, and boundary-lines are also tinted with their respective colors.

The finished concept-sheets are deposited in the war archives, where they are kept and photographed. Next, the irregularities of the ground are examined, and the photographs serve to make up plans for the check as well as the detail leveling.

All elevations are, as mentioned before, taken with the level. One or more check-lines are at first run through the territory, which is done with the utmost degree of accuracy. The same line is simultaneously examined by two persons, (each with his instrument,) who constantly compare notes with one another, and as soon as any noteworthy difference appears they at once re-level that part of the line passed over since the last checking took place. In that way every error, even the smallest, is discovered, and thus can the final error for a line of 100 to 150 kilometers be reduced to a mere trifle. On the check-line are established numerous bench-marks which are afterwards to form starting-points for the detail-lines. They are by preference chosen at or near by road-crossings, and are fully described in the notes, being placed on rocks or immovable stones, on the foundations of church walls, stone bridges, or in other places where it can be assumed that they will remain uninjured by time or human hands.

Errors are distributed for the check-lines separately, with the sea-level for starting and termination points. Thus the observations of the water-height which have been taken during a long succession of years several times a day, and are still made at certain light-houses along the coast, serve to establish the mean water-level from which the elevations are reckoned. From these bench-marks starts the detail examination which forms a net of surveyed lines over the whole country, through which a perpetual control of the accuracy of the survey is obtained. Only an error of 0.2 or 0.3 meters is allowed in the control survey, and if the excess is greater a resurvey is made. The distribution of errors takes place between the check-lines, through whose altitudes, which are as nearly as possible absolutely correct, values of the actual errors of the detail-lines are obtained. From these lines of the second order branch on each side numerous smaller ones for getting the elevations of isolated points, running streams, and other objects, which values are in their turn corrected after all errors are distributed.

To this examination of ground irregularities great attention is paid in Sweden, as can be seen by a glance at the special map, where generally all, even the smallest, waters are examined, and seldom any point of note is left without an elevation figure. It is also performed with a considerable degree of accuracy. All these figures are put down on the concept-map on the scale 1 : 50000, which is now reduced to 1 : 100000, or the scale in which the atlas is published. The altitude figures serve now for connection and control in the reduction of the ground, which must of course agree with them. The reduction is made partly with a

pantograph (the contours) and partly by squares. The map is finished in india-ink, and is colored like the concept.

This reduction is a work which requires much experience and judgment, as will be easily seen when it is considered that there is only one-quarter of the space on the concept for representing the same thing. When, therefore, as is often the case, the concept-map is already overloaded with objects, many of which cannot be shown on the reduced scale, a selection must be made and the important be set forth at the expense of the unimportant.

One must exclude in one place and crowd together in another, but all this so that the main character of the map is not lost, and that the whole receives its proper appearance and size, though portions should here and there have to be somewhat deformed and altered. The elevation figures demand also some change. All this requires more practice and discrimination than most other topographical work.

The reason why this apparently unnecessary reduction is undertaken, is the great expense of the engraving of the map, which is drawn on copper, and which, on the scale 1 : 50000, would be nearly four times as expensive as on the scale 1 : 100000; besides, it would take four times as long to complete it.

ENGRAVING AND PUBLISHING.

Before 1857 the map on the scale 1 : 100000 was kept secret. At first there were only hand-made copies of it, but in 1826 it was ordered that it should be engraved, the work to be done by officers of the topographical corps, who, after taking the "service-oath," were to be responsible for the secrecy of the map during the engraving, as well as during and after the printing. It was engraved on copper, and, with the exception of names, by etching. When the government in 1857, on the recommendation of the chief of the corps, permitted the publication of the map, there were 20 of those sheets engraved by etching, which were, on account of the age of the concept-map, regarded as not fit to be published, while 11 were published after having been previously tested in the field.

The engraving of the later sheets is done with the graver by copper-engravers, some of whom are employed in the corps, and some work on contract. In this way 37 sheets have been engraved since 1857.

The Swedish general staff intends in future to use, instead of copper engraving, the Austrian Mariotte's Heliography method, which has been purchased by the Swedish government. Experiments with it on a large scale are at present in operation.

In accordance with a royal order of 1833, the Hermelin Atlas was transferred from the land-survey office to the topographical corps, with instructions that the net income from the sale of the maps should be used for compiling "lån" [5]maps on a scale of 1 : 200000. It had been the duty of the topographical corps since 1832 to compile as the military atlas was progressing, and with the use of the same as material, an atlas of the låns of Sweden, on the scale 1 : 200000, accompanied by statistical descriptions. Of this atlas maps of 10 låns have been published since 1841, comprising 15 sheets, all engraved on copper with the graver. As the designation of the irregularities of the ground makes a map expensive, and by many buyers is regarded as valueless, it was excluded on the last map of "Calmar lån," issued on two sheets in 1871.

In the following year the government ordered that the work on this atlas should be discontinued till further orders.

A general map on a smaller scale should properly be the last link of all the above-mentioned works, and the need of it had so frequently shown itself that it was not thought advisable to wait until the completion of the whole atlas. The general map of Sweden, on the scale of 1 : 1000000, has been in active preparation since 1865. It is to be published in three sheets, of which the southern has been obtainable since 1870 at the book-stores. The two other sheets are in process of preparation.

COST.

Let me refer, concerning the cost of the geodetic and topographical work executed in Sweden, to the attached table, which contains the total cost of these works, and also an account of the yearly expenses from 1858 to 1874, inclusive.

The same table shows that the yearly appropriation from 1869 to 1874, inclusive, has been 60,000 Swedish crowns, or $16,000. The appropriation for the present year is the same; but from and including the year 1876 it will be 75,000 Swedish crowns, or $20,000[6] approximately.

THE ECONOMY MAP ESTABLISHMENT OF SWEDEN.

This establishment, the main object of which is to obtain an accurate knowledge of the area of the kingdom and of the economic condition and distribution of this area, was established in 1859. The General Land Survey Office has had the superintendence of it up to 1873, when it was placed under the direction of the chief of the topographical division of the general staff.

The Economy Map Establishment has ever since its organization been managed in two divisions: one for the southern and central parts of the country and one for "Norrbotten lån," which, comprising the northmost part of the country, makes a special map-work necessary on account of its vast extent and its slight cultivation. The division first mentioned prepares its concept maps on the scale 1 : 20000. In "Norrbotten lån," where the surveys have at the same time a topographical object, the scales 1 : 20000, 1 : 40000, and 1 : 50000 are used; the last, however, only in "Lappmarken."

Between 1860 and 1874, 26,850 square kilometers of Central Sweden have been surveyed and 70,800 square kilometers of Norrbotten lån. The maps of Southern and Central Sweden are published by the "harad"[7] on the scale 1 : 50000. There are already published maps of the whole of Upsal and Örebro lån, of some hårads of the Great Copperbergs and Stockholm lån, and of part of the province of East Gothland. Five "härad maps" of Norrbotten lån on the scale 1 : 100000 have been published.

Although the surveys for the maps are carried on by appropriations from the government, their publication, as far as concerns the southern and central parts of the country, depends upon applications made by "economy societies" or communities, who then pay the expenses.

The government appropriation for the coming year (1876) is 87,000 crowns, ($23,200[6],) of which 30,000 crowns ($8,000) are for Norrbotten.

Two officers of the general staff are appointed to direct the work of the Economy Map Establishment. The force consists besides of 19 cartographers and 11 persons who do the drawing, among whom are 8 ladies.

The work done by this establishment for the preparation of the skeleton map, on the scales 1 : 20000 or 1 : 40000 may be divided into—

a. Transferring of homestead-maps.—All recent land-surveyors' maps of homesteads, situated in a locality where an economy map is to be made, (which locality is decided on by the chief of the topographical division of the general staff with a view to the requirements of the topographical work,) are transferred to the scale 1 : 20000. Lake charts are also transferred when they can be procured. This work is done during the winter. County-surveyors' maps which are missing are looked up in the county-surveyors' offices of the låns or at private farm-owners', and are transferred where found.

b. The field-work.—The plats thus obtained are compared by the surveyor with the corresponding objects in the field, and such changes as have occurred since the survey of the plats, as newly-broken lands, additional and removed houses, drained lakes, morasses, and marshes, roads built or destroyed, &c., are ascertained and marked. Various objects which are not distinctly marked on the common land-survey maps, as dwelling-houses, forest-roads, foliage, pine-woods, orchards, &c., are located and sketched in, so that the map becomes a perfect plane-image of the ground, with its artificial and natural objects. For this work is used either the common plane-table, with index-ruler, or the stadia. Those homesteads of which no land-survey map can be obtained, as well as places near the coast of which no reliable lake chart exists, are surveyed on the scale either of 1 : 20000 or of 1 : 8000. In the latter case they are afterwards reduced to the scale 1 : 20000. In this survey the stadia is used after one or more base-lines have been first staked out and chained. Triangulation points, necessary for the putting together of the plats, are located on the map. The conventional signs for different objects are almost the same as those adopted for the topographical maps. The principal differences are that homestead limits are indicated, that dwelling-houses are colored red, cultivated lands yellow, meadow green, marsh and morass brown. These latter are, besides, ruled with broken parallel lines of india ink.

c. The putting together of the map.—In order to connect these revised and corrected copies and newly-surveyed maps satisfactorily, a secondary triangulation is needed, to furnish a sufficient number of base-points. This triangulation is, as stated before, executed by the topographical division of the general staff, as it is regarded necessary to have, if possible, at least three points determined within every 100 square kilometers.

The arrangement of the economy maps is made in conformity with that fixed for the topographical map of Sweden, in such a way that one sheet of this map on the scale 1 : 100000 includes twenty-five sheets of the economy map on the scale 1 : 20000, each representing an area of 105.82 square kilometers, and measuring 594^{mm} in length by 445^{mm} in width. For putting together the map, on a large table a net of rectangles is constructed of the size designed for the sheets. Within these rectangles the triangulation-points are plotted from their co-ordinates, calculated with reference to the sides of the said rectangles, after which the corresponding located triangulation-points on the homestead-plats are fastened with needles directly over the located points. In the intervals between the plats thus secured all the rest are fitted in the usual manner, so that they meet snug at the borders. When they are all fitted together properly they are fastened with mouth-glue, after which the map is cut into sheets. These sheets are now completed in what may be wanting in the drawing and by naming all the objects on them. Each sheet is

named after its most prominent place, and retains also the name of the topographical sheet on the scale 1 : 100000, within which it is situated.

d. Drawing up of descriptions.—All whole and fractional parishes on the sheet have their areas calculated and corrected: first, for the error caused by the shrinking of the sheet, and next for the inequality which arises between the total area of the parishes put together, and the area which the whole sheet should represent. Here it should be remarked that the stated area of 105.82 square kilometers on each sheet, which makes a part of the conical projection surface on which the triangulation net of the country is constructed, differs more or less in size at different degrees of latitude from the corresponding area on the ground, so that it must be reduced with the aid of a previously prepared reduction-table to the corresponding real area on the earth's surface. The areas of all entire homesteads and fractions of such, which are included on the sheet, are also calculated and corrected by the parish, so that the total area of the homesteads within each parish will be equal to the area of the same parish obtained in the manner above stated. The areas of the homesteads and parishes are computed partly with the circular planimeter and partly with the polar planimeter.

These statements are entered in the "härad descriptions," which contain besides the name and nature (frälsekrono or skatte) of the homesteads and localities, and for each homestead the areas of lots, orchards, cultivated fields, meadow, timbered and cleared lands, roads, sterile morasses, barren mountains, obstructions, lakes, water sources, &c., and notes on matters of special importance at each homestead.

The economy and topographical mapping of Lappmarken, in the lån of North Bothnia, on the scales 1 : 20000 and 1 : 50000, represents, for the most part, an entirely new survey of this part of the country, as the previously made land-survey maps are quite scarce. As bases for this survey and mapping, the positions of a large number of points in the southern part of Lappmarken were determined astronomically in 1860, 1861, and 1862, and a minute triangulation was executed in later years of the central and northern parts.

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Summary of expenses of the Swedish topographical atlas.

Year.	Appropriation per year.	Triangulation.	Astronomical location.	Field survey and levelling in various scales.	Map of Sweden, (engraving, paper, plates, and coloring.)	Skeleton-map works in the country.	The 1an map work, (gross.)	Winter work.	The war archives.	Traveling for inspection.	Salaries to extra assistants.	Rent.	Sundry.	Total.
	Or. öre.	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*	*Or. öre.*
1812 to 1857	.....	93, 946 74	14, 223 89	318, 549 20	32, 845 23	42, 289 68	74, 249 29	28, 615 17	37, 066 93	16, 886 65	.....	.....	44, 309 75	692, 975 52
1858	27, 800	615 81	.....	21, 564 74	510 00	.....	1, 886 90	2, 643 01	1, 734 65	1, 758 99	.....	.....	5, 776 90	35, 491 00
1859	27, 800	.....	.....	17, 500 68	3, 457 01	.....	6, 379 85	2, 548 32	4, 922 61	113 76	2, 750 00	2, 112 48	1, 090 00	40, 874 71
1860	27, 800	.....	.....	9, 570 64	7, 702 00	.....	4, 867 12	120 00	2, 779 37	549 39	3, 085 01	1, 560 84	3, 586 63	33, 821 00
1861	53, 200	2, 844 93	.....	13, 143 57	12, 099 75	.....	1, 707 65	1, 311 17	2, 034 65	864 34	3, 200 00	2, 481 67	8, 960 44	48, 646 97
1862	53, 200	1, 509 73	.....	24, 113 35	12, 021 34	.....	1, 480 50	2, 649 19	2, 391 57	801 00	3, 200 00	2, 052 25	4, 737 69	54, 956 62
1863	53, 200	.....	.....	26, 778 65	11, 213 07	.....	1, 395 00	6, 541 67	1, 313 39	986 54	6, 437 68	3, 251 12	1, 990 61	59, 907 73
1864	53, 200	4, 536 33	.....	17, 938 13	12, 370 30	2, 983 01	872 06	6, 297 74	2, 480 96	956 97	4, 430 00	3, 267 57	3, 565 75	59, 698 11
1865	53, 200	5, 224 33	.....	23, 852 80	13, 774 73	747 14	743 75	6, 569 33	2, 311 98	661 21	4, 110 00	3, 612 81	4, 068 58	65, 656 66
1866	53, 200	.....	.....	23, 918 57	15, 519 05	4, 277 54	1, 056 53	7, 352 32	3, 018 25	1, 259 93	4, 705 00	3, 248 28	1, 028 47	64, 376 64
1867	75, 000	.....	.....	37, 893 23	15, 875 09	310 60	694 10	6, 763 98	1, 939 35	605 94	4, 912 50	3, 421 45	4, 311 25	72, 973 43
1868	75, 000	6, 946 24	.....	15, 663 83	16, 231 96	1, 649 48	1, 576 18	3, 115 50	4, 491 79	798 41	6, 730 67	4, 095 41	2, 973 02	66, 230 31
1869	60, 000	8, 904 06	.....	24, 263 17	11, 877 10	.....	692 00	2, 714 32	2, 376 67	538 24	6, 982 50	4, 945 77	3, 252 81	67, 218 22
1870	60, 000	9, 577 34	.....	18, 156 67	20, 949 86	3, 765 44	2, 323 75	2, 883 70	2, 036 41	525 25	4, 085 00	3, 636 19	5, 096 87	67, 870 09
1871	60, 000	4, 413 95	.....	15, 842 74	19, 636 73	.....	1, 364 15	3, 932 80	1, 902 65	566 94	3, 817 50	1, 677 15	5, 165 64	55, 978 93
1872	60, 000	2, 072 63	.....	23, 011 98	17, 041 92	.....	457 00	4, 772 50	1, 792 48	717 23	4, 783 33	2, 978 33	5, 098 76	64, 110 02
1873	60, 000	4, 457 13	.....	17, 339 16	15, 299 35	2, 927 57	866 00	7, 250 72	2, 234 11	438 83	4, 457 50	6, 259 48	7, 970 54	68, 128 43
1874	60, 000	3, 162 23	.....	16, 671 15	17, 737 29	2, 584 17	848 50	6, 377 35	.....	312 30	5, 596 67	633 00	10, 361 67	63, 883 94
		150, 273 29	14, 223 89	653, 770 56	256, 074 77	61, 534 57	103, 432 43	102, 458 73	66, 827 22	28, 341 22	73, 283 36	49, 233 56	123, 345 37	1, 682, 799 03

1 Swedish crown = 26 85-100 cts. gold.

REMARKS.

1. That the total expenses for the year mostly exceed the appropriation proper depends upon the income from sale of maps, &c.
2. The expenses of the war archives are principally purchase of books, maps, instruments, and inventories, besides expenses above the ordinary appropriation.

NOTES AND EXPLANATIONS.

1. Sweden is divided into three principal parts, viz, Svea-land, the central part Gotha-land, the southern, and Norr-land, the northern part of the country.
2. "The royal majesty" is an expression very commonly used for "the government," the state, the highest authority, or "the crown."
3. "Hemman" is a part of a parish, and may be translated by the word "homestead."
4. The Swedish word "Kartwerk" means both an atlas and an establishment for making maps.
5. The kingdom is divided into 25 läns, each under the authority of a governor.
6. This estimate is given in gold. It is given in round numbers, as, according to close calculation, 1,000 Swedish crowns = $268½ gold.
7. "Härad" is a subdivision of the "län."
8. Homesteads (hemman) are of three kinds, "frälse," "krono," and "skatte" hemman, which names indicate, respectively, tax-free, crown, (or government,) and tax-paying homesteads.
9. One Swedish crown (krona) is divided into one hundred parts called öre.
10. å, ä (or ā) and ö (or ō) are the three last letters in the Swedish alphabet, and are pronounced respectively as *o* in for, *a* in cast, blast, and *i* in first, bird.—[TRANSLATOR.]

§ 2. NOTES ON TOPOGRAPHICAL MAPS OF SWEDEN.

The area of Sweden is 170,101 square miles. For administrative purposes it is divided into three districts called "poiks;" these are subdivided into läns, which correspond to our counties, and the läns are divided into härads and söckens.

There have been sent to this office for examination an index-sheet, on which there is also a table of conventional signs, several sheets showing the state of the triangulation, surveys, and publication at different dates: one sheet of a general chart of Sweden on a scale of 1 : 1000000; forty-eight sheets of the topographical map of Sweden on a scale of 1 : 100000; thirteen län-charts on a scale of 1 : 200000; and two härad charts, one on the scale of 1 : 50000, and the other on that of 1 : 100000.

THE GENERAL CHART.

This is on a scale of 1 : 1000000. The projection is so made that the sheets can be joined together and mounted, making a single map. The lines representing the whole degrees of longitude (reckoned from Stockholm observatory) and of latitude are drawn, and the border is divided into 5′ spaces. The lower border is further divided into spaces representing the longitude east from Ferro. In this map are shown, by the usual conventional signs, the water-courses, lakes, cities, towns, villages, castles, railroads, post-roads, iron and copper mines, and boundary-lines of the civil divisions. The water is colored blue, and the boundary-lines are shaded in different colors. The names of the civil divisions are not printed on the map proper, but the läns are numbered by the Roman notation, and the härads by the Arabic, and the names corresponding to these numbers are printed on the side of the sheet. The relief is shown by hachures, and by printing the exact altitudes of various points on the map.

THE TOPOGRAPHICAL CHART.

The scale is 1 : 100000. This map is engraved on copper and is published in rectangular sheets, each of which represents an area of 59.4 by 40.5 kilometers. The rectangles are formed by drawing lines parallel and perpendicular to the meridian, which is 5° west of Stockholm. This is taken as the central meridian in the projection of all the sheets. The rows of rectangles are numbered from the central meridian to the

east and west, and from the north to the south, so that the position of the sheet is shown by printing on it the number of the row east or west in Roman numbers, that of the row from the north in Arabic numbers; *e. g.*, "IV E. 31." The lines representing the parallels and meridians at distances of 10′ apart are drawn, and the border is further divided into 1′ spaces. Scales of meters and Swedish miles are given. The sheets, which are clear and handsome, give a very detailed representation of the natural and artificial features of the country, showing by appropriate topographical signs the water-courses, canals, lakes, ponds, marshes, railroads, post-roads, common roads, bye-roads, stone bridges, wooden bridges, light-houses, anchoring-grounds, cities, towns, villages, churches, castles, mills, farm-houses, forests, woods; silver, copper, and iron mines, telegraph-lines, and the boundary-lines of the various divisions. The water and boundary lines are colored. The relief is shown by hachures, and by writing the heights of the prominent elevations, and of numerous other points along the roads and streams. On the sea-coast there are also hydrographic charts, the depths being given for a distance of about one Swedish mile (6.65 English miles) from the shore. The curves of 10, 20, and in some places of 25 and 30 feet depth, are drawn. Beyond these the depths are given in fathoms.

HÄRAD PLANS.

These are colored lithographs, and appear to be made for cadastral purposes, as property boundaries and the limits of cultivated, waste, and meadow-lands are shown; and each sheet contains a table giving the areas of the different classes of land and of the water in each söcken. The relief is not indicated nor are soundings given; otherwise the plans show about the same features as the topographical charts.

LÄN MAPS.

These maps, on a scale of 1 : 200,000, are engraved on copper. The water and boundary lines are colored. The härads are designated by Roman numerals, and the corresponding names are found at the side of the sheet. The principal features represented are the water-courses, lakes, marshes, cities, towns, villages, manor-houses, farm-houses, court-houses, mills, mines, railroads, turnpikes and common roads, canals, light-houses, triangulation-points, and anchorage-grounds. The relief is shown by hachures and by the written altitudes of a few points. At the sides of the sheets are engraved plans of the principal towns and the country immediately surrounding them on a scale of 1 : 20,000. An index to the conventional signs employed is printed on each sheet.

Compiled by Lieut. P. M. Price, United States Engineers.

§ 3. Notes on Norwegian Maps.

Norway has an area of about 123,000 square miles. For administration purposes it is divided into five stiften or provinces, which are subdivided into 17 amts or counties. The smaller subdivisions in order of size are fogdeir, praestegjelds or parishes, and anneks. Eight distinct series of maps and charts are published. Of these there have been sent to this office for examination seven index and progress sheets, two of which show the primary and secondary triangles; six sheets of the general chart of Southern Norway on a scale of 1 : 400000; 25 sheets of the amt charts on a scale of 1:200000; 12 sheets of the general topograph-

ical charts on a scale of 1:100000; five sheets of a general chart of the Norwegian coast on scales of 1:350000 and 1:800000; 13 sheets of a second general chart of the coast on a scale of 1:200000; 11 sheets of a coast-chart showing, by colors, the character of the bottom, on scales of 1:100000 and 1:200000; 12 sheets of a special chart of the coast on a scale of 1:100000; and 18 sheets of a second special chart on a scale of 1:50000.

Longitude on all the charts is reckoned from Christiana observatory, but the longitudes from Paris, Greenwich, and Fërro are shown on the borders of most of the charts.

GENERAL CHART OF SOUTHERN NORWAY.

The scale is 1:400000. The chart is published in rectangles, each of which represents an area of 16 by 13 Norwegian miles, (one Norwegian mile equal to 7.017 English miles.) The sheets are lithographs. The water is in blue, the roads and towns are in red, and the boundary-lines and contours in black. These are about the only features represented. The chart is published in two styles, the relief being shown in one series by contour-lines and by numbers giving the altitudes of the most prominent elevations, and in the other brown shading is employed in addition to the above methods.

TOPOGRAPHICAL CHART.

The scale is 1:100000. This chart is also lithographed and published in rectangles, each of which represents an area of 4 by 3 Norwegian miles. The rectangles are numbered, and are also named from the principal town contained in each. The meridians and parallels at distances of 10′ apart are drawn, and the border is divided into 1′ spaces. Scales of Norwegian and geographical miles and of feet and meters are given. The names of the adjoining rectangles are printed on the margin at the four sides.

The sheets are accompanied by an index-chart, which also contains a table of the topographical signs employed. The charts are quite detailed, and in general give a clear representation of the country, although the large number of names written in the more thickly settled portions somewhat diminishes the distinctness. The charts show by appropriate topographical signs the boundary-lines of the various civil divisions, the cities, towns, villages, churches, manor and farm houses, fisheries, water, saw, and wind mills; iron, copper, silver, and glass works; manufactories, brick-kilns, drill-grounds, trigonometrical points, post and common roads, railroads, telegraph-lines, water-courses, lakes, marshes, canals, light-houses, buoys, and anchoring-grounds. The water is colored blue. The relief is shown by horizontal curves 100 feet apart in vertical distance, and by numbers giving the absolute altitudes of various points, and in addition to these methods the hills are shaded in brown. The depths along the sea-coast are given in fathoms.

AMT CHARTS.

The scale is 1:200000. Some of these charts are copper engravings, others lithographs.

The sheets are not of uniform size, one amt being in some cases represented on a single sheet, and in others on two or more. They show about the same features as the topographical charts, but the names are not given with so much detail. The relief is shown by shaded con-

tours. Plans of the larger cities, on a scale of 1:20000, are drawn at the sides of the sheets inside of the border.

Each chart has printed upon it a table of altitudes, giving the heights of prominent points, lakes, &c.; a table giving the areas in Norwegian miles of the civil divisions; tables giving the parts of which the various civil and judicial districts are composed; and a table of conventional signs.

SEA-COAST CHARTS.

There are five series of these:

1st. These are charts of the sea-banks along the Norwegian coast, on scales of 1:100000 and 1:200000. The form of the bottom is shown by contour lines 10 feet apart, and the character of the bottom by different colors and signs, indicating fine sand, sand, gravel, clay, stones, rock, &c. The contours and colors are not carried to the shore, but extend from a distance of $\frac{1}{4}$ to 1 Norwegian mile from the shore outwards. Depths from these points to the shore and intermediate depths are shown by figures. The land is indicated by parallel black lines drawn very close to each other, and the only topographical features shown are the towns and hamlets on the sea-shore, a few of the prominent hills, and the light-houses. A representation of the card of the mariners' compass, showing the directions of the 32 points, reckoned from the magnetic meridian, is given on each chart.

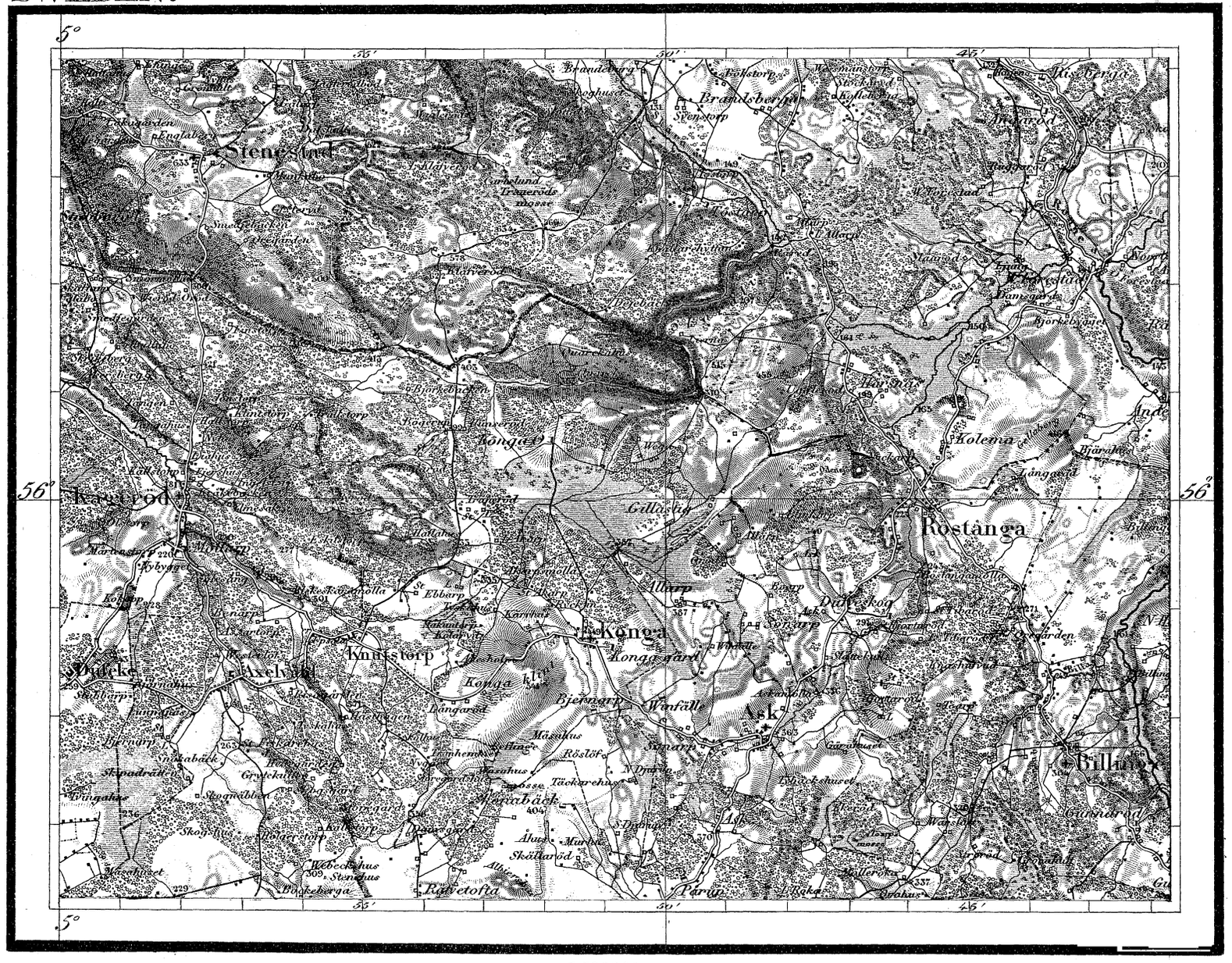
A sheet showing the profiles of the bottom between various points accompanies this series.

2d. The remaining four series of charts consist of two series, A and B, of general charts, the first on scales of 1:350000 and 1:800000, the second on a scale of 1:200000; and of two series, A and B, of special charts, the first on a scale of 1:100000; and the second on a scale of 1:50000. The two last series had not been completed in 1872. These are all sailing-charts, and present the same general features, differing from each other mainly in greater clearness and amount of detail of those on the larger scales, so that a general description will apply to all. A detailed description of each series would necessitate describing separately nearly every sheet, as a uniform system of publication does not seem to have been adopted, even for charts of the same series. The larger number of the charts are engraved, the rest are lithographs.

In general the topographical features of but a narrow strip along the shore are represented, and on many of the charts nothing is drawn but the shore-line, the towns and hamlets on it, and some of the prominent hills, and light-houses. The soundings are given in fathoms. The character of the bottom is indicated by letters, and the positions of buoys, sunken rocks, and shoals are shown by conventional signs. On most of the sheets elevations of the light-houses are drawn, and on many of them sketches showing the appearance of the shore from the sea. The deviation of the needle at various points is given, and at most of them a diagram is drawn, showing the directions of the 32 points of the compass, taking into account this deviation.

Circles are drawn with the light-houses as centers, showing the limits of visibility of the light, and the characters of the lights are either written along the circumferences of these circles, or on some other part of the sheet. On many of the special charts sailing-directions are written, and the compass-bearings between different points given.

Compiled by Lieut. P. M. Price, Corps of Engineers.



CHAPTER IX.

§ 1. Notes on Topographical Maps of Belgium.

Two sheets furnished for examination. Scale of the published maps, 1:40000; size of sheets, $31\frac{1}{8}$ by $19\frac{1}{2}$ inches; area represented on each sheet, 32,000 meters east and west by 20,000 meters north and south. The work is engraved on copper. Meridians and parallels are drawn for every 5′ of arc, and the exact latitude and longitude of the corners (N. E., N. W., S. E., S. W.) of the area represented are given on each sheet. The sheets are numbered and named at top, the name being that of the most prominent town or village represented. The number serves to locate the sheet in connection with the adjoining sheets, as indicated by a diagram giving the numbers of the maps of the adjacent territory.

Meter, league, and marine-league scales are given at bottom of the sheet. Contours are drawn for every 5^m of elevation, and the heights of prominent points are given in meters.

Railroads, common roads, by-ways, and paths, streams, cultivation, forests, woods, quarries, bridges, and isolated houses are indicated.

The positions of triangulation-stations and bench-marks are also given.

The nomenclature is detailed, giving names of roads and railroads, of streams, villages, and detached houses. Water is indicated by lines of shading, not by colors. Numerous conventional signs are used to indicate trees, forests, cultivation, battle-fields, &c.

Authorities.—Two Belgian maps.

Compiled by H M. Adams, captain of engineers.